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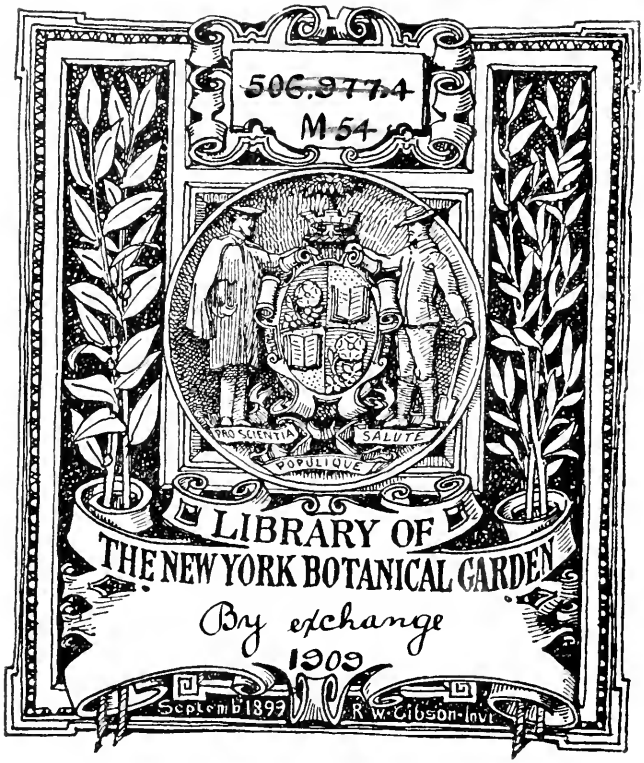
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ELEVENTH REPORT

OF

THE MICHIGAN ACADEMY OF SCIENCE

CONTAINING AN ACCOUNT OF THE ANNUAL MEETING

HELD AT

ANN ARBOR, MARCH 31, APRIL 1 AND 2, 1909.

DARWIN CENTENARY PUBLICATION

PREPARED UNDER THE DIRECTION OF THE COUNCIL

BY

GEO. D. SHAFER
ACTING SECRETARY

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LETTER OF TRANSMITTAL.

To Hon. Fred M. Warner, *Governor of the State of Michigan:*

Sir—I have the honor to submit herewith the Eleventh Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,

Geo. D. Shafer,

Acting Secretary of the Michigan Academy of Science.

East Lansing, Mich., June 16, 1909.

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MAR - 1910

PRESIDENT'S ADDRESS.

THE BEGINNINGS OF LIFE FROM THE VIEW POINT OF A BACTERIOLOGIST.

CHARLES E. MARSHALL.

At the very outset, one diversive thought appeals to me for recognition. In an untechnical or popular development of a general conception or idea such as is designed in this address, evidence which provides substantiation can only be inferred, and cannot be subjected to a satisfactory and critical review. This feature will cause a mental jolt to the investigator who would seek the basis for every statement, but, on the other hand, it has been planned to deal with an audience of general scientific training, rather than specialists who are more or less thoroughly familiar with the material which we have to offer.

In undertaking to consider "The Beginnings of Life," I find it pertinent and desirable to recall, very briefly and generally, some historical thoughts, lest I be misunderstood in my effort to cast some light on the problem assigned me. I have no wish to discuss such intangible subjects as the creation of life, but rather to state some of the fundamental principles concerning the life which has already been furnished, to trace that life in its simplest manifestations as it is suggested by the branch of science called bacteriology; for, is it not true, that whatever knowledge science may provide in any of its branches, such knowledge is useful in every branch? I shall seek upon this occasion to have this discussion present a setting in the times, the life, and the thoughts of Darwin.

So firmly bound together were religion and science, especially in this theme, "The Beginnings of Life," fifty years ago, that the one could scarcely be considered without prejudice, unless the other was, to some degree, involved. The ideas were indissoluble. The church had permitted its arms, amoeba-like, to gradually reach out and incorporate everything within itself, and had begun the process of assimilation, when it was shocked by a morsel, poisonous to it, which would not yield to absorption; consequently, its arms flowed back to discharge the effete matter—in this instance, the morsel was science. This check has redounded creditably, however, to each—religion and science. They both have grown more glorious and wholesome with the passing of years, the church, from its "Middle Ages" decadence, and science, from its superstition and haphazard practices.

Courage in conviction, time for adjustment, and patience in action were required to bring to an end this bloodless revolution—a revolution of thought fought by means of scientific facts on the one hand, and a demagogery of the church on the other. The strife is largely over, and all church men and scientists, alike, are enjoying the results of the outcome. As we turn our

eyes upon those struggles of intellect, we cannot help feeling a keen admiration for the generals who guided them. At this moment, our minds center about the general-in-chief, Darwin, but close by his side were many worthy aids as Wallace, Hooker, Huxley, each deserving commendation for his part.

Although spiritists and scientists have considered life and its beginnings from two distinct view points, when the time shall arrive to take an inventory of knowledge in the fields of spiritism and materialism, it will doubtless be shown that ignorance, alone, was and is the real cause of separation. The growth of knowledge will have its mollifying influence upon any harshness or enmity which may have arisen through blind judgment and false conclusions. Spiritism is going out to seek the facts of nature, and science, as science is, has never failed to recognize the gist of spiritism. That state of the popular mind which was responsible for the production of White's "History of Warfare of Science with Theology in Christendom," and Drummond's "Natural Law in the Spiritual World," has passed away and in its place has sprung up a mental condition which cries constantly for the truth without any attempt to select that truth by preconceived notions. Adjustments and readjustments have been necessary from time to time, and they have caused alarm momentarily, but in a retrospect of fifty years, even the most extreme of active partisans cannot regret the changes.

Nature before Darwin was a mere mud hut, but Darwin made it a cathedral; he took the material available, arranged it carefully and logically into such forms that when seen in its natural setting, it was easy of interpretation; therefore, could be admired and understood. While he did not and could not make his scheme or plan complete—for such is not within the power of any man—he so left it that intelligent direction could be given and safe deductions drawn. If the power to appreciate is measured by the extent of knowledge, then Darwin has made it possible to appreciate Nature in such a manner as no one previous to him had done. The fund of information left by him reveals, in its fulness, the beauty of the architecture involved in this cathedral. As the structure has evolved from a mud hut to the magnificent edifice, in like proportions have we seen evolved, also, that which Darwin was then considered to so antagonize—the morale of man. Before Darwin, Nature was accepted; by Darwin, Nature was revealed, and through those who followed him, Nature will be understood, thus exalting the Handiwork of the Creator in the eyes of men.

Life! Whence came it and whither does it lead? What is it that makes it so enigmatical, so elusive? Shall we seek for an answer in spiritism? This is outside of our purpose, and cannot be considered in connection with our theme. Shall we look for the answer in some such subtile force as affinity, electricity, radio-activity, magnetism, or in some other quality, property, or concept of matter; or, is it a composite of these minor unknowables in one grand, supreme unknowable? I say unknowable, because we must not forget that much of our ultimate knowledge is little more than formulated words and expressions to cover our ignorance. Huxley was honest in his treatment of the "Physical Basis of Life," for he breathed into every line his helplessness in coping with the final analysis which his adversaries insisted that he make, and even affirmed that he made. It is plain in these days to the most superficial reader that he brought his gigantic intellect to aid in teaching the masses the beauties and possibilities of life as depicted by or through him and in extending the horizon of men's visions which had become or were so dwarfed and atrophied. Huxley made

no serious attempt to explain the step involved in the origin of life or its creation. Darwin cannot be charged with any efforts to fathom the real mysteries of life. His was not a mind to hypothesize without facts, or to speculate without reasons; he was naturally disposed to deal with matters as they came to him and to study them in the light of their environment. He traced every line of thought through a wilderness of facts, consecutively, to divulge its real meaning and its associations; he noted every point to establish its significance, and, when done, he based his conclusions upon the matured and developed idea interpreted not in its isolation, but in its relation to nature. To his mind, induction meant serious, heavy, and prolonged labor; deduction, easy and intuitive recreation. By inference, therefore, much has been attributed to Darwin and his co-workers that does not exist. Doubtlessly, they have speculated some, but this was not the serious side of their lives' tasks. It would not be a suitable commemorative service, therefore, were we to emphasize that feature of Darwin's life, which represented a small fragment of his thoughts, by trying to tell what life is. It would be more devout and respectful to study some of the simplest forms of life as to their functional activities and structure.

The invisible world is of vast extent, and very rich in life. So common is it to measure everything by our own knowledge, our own conviction, and our own experiences that we frequently forget that much may lie beyond the boundaries of the individual; that worlds may exist without the consciousness of the individual. The branch of science known as bacteriology represents, to a greater or less extent, the integral life of the invisible world; it has been so busy in the short period of its existence as such with the many economical problems that comparatively little attention has been given to the general biological matters with which it is pregnant. The simplicity of the life studied or constituting the material of the subject, bacteriology, must appeal to the general biologist as possessing advantages over higher life forms with their complicated associational factors.

The life form is a single cell. All the functions and structures are confined within this cell. This independent cell acts as any individual organism, as an entity. Many of these unicellular organisms yield readily to pure culture cultivation through an indefinite number of generations; their habits are open constantly to observation. They may pass through cycles of development to suit the convenience of the student, and the research man. Their metabolism is subject to absolute measurement. All functions and structures common to living cells in animals and plants appear to be present in these organisms; accordingly, there seems to be ground for the belief that the realm of unicellular life will provide the proper material for the beginning and basic study of life forms. In these reasons will be found, also, the motive for undertaking to analyze some of the vital phenomena as corroborative and useful in understanding the more complex living forms.

The principle of the lever is simple when studied by itself, but introduce it into intricate engines, mechanical devices, and other contrivances, and it either fails of detection or becomes involved in other parts and problems. So frought with difficulties from association and specialization are the cells which form the structure of high or complex life forms that the life represented in the cell can scarcely be detached from the life structure of which it forms a part. The cell, in this instance, plays a subordinate rôle, and yet it is an essential part or unit of the organism possessing it. Like the lever, the cell contains the principal, but it becomes greatly involved when made only a member of a composite body.

Economically, the study of unicellular life has made itself felt in general biological studies. It has thrown light upon many of the phenomena of life which, heretofore, were not well understood, and has added many new biological discoveries, largely because the cell was more basic and more simple; thus, more susceptible to ready solution. Mere mention can be made of a very few of these matters in this cursive presentation, but even this must lend concreteness and force to the importance of such contributions. The impetus given to the study of fermentation and diseases by Pasteur and the interpretation of them have in one way and another initiated a new regime in the field of biology. The work of Metchnikoff with phagocytes has not only been the means of centering considerable attention and effort upon these cells and their functions, but has caused a more exhaustive study of blood corpuscular elements, so that today the knowledge thus acquired shapes itself into a dignified branch of science which is of great usefulness. The study of toxins by Koch, Kitasato, and Von Behring has stimulated others to activity in similar lines in the field of botany and zoology. With the advent of Roux, Ehrlich, and many others, in their most skilful studies of anti-toxins, old notions of vital cellular and molecular reactions were swept away and new ones substituted. Out of these investigations, the blood reactions, emanating from a knowledge of agglutinins and similar bodies possessing specific action, have extended the field of general biological knowledge. Many illustrations of kindred lines of development may be cited to indicate the trend of unicellular studies, but these will suffice for our purpose, inasmuch as they point to the molecular interpretation of cell activity.

We pass now from a more general to a more intimate characterization of our subject and our thoughts will center upon the cell. Two distinct lines of thought arise for consideration in bringing unicellular life forms into relief for the purpose of discussing their relation to life's beginnings. The one, the functional, which in our interpretation will be regarded as basic; the other, the structural, or morphological, which will be regarded in a large measure dependent upon the functional. By these two concepts everything utilized in this paper will be measured, because most ideas bearing upon this subject will fall readily into one of the two classes.

It is customary to deal with the structural cytology of micro-organisms before designating the physiology, but for the present I desire to reverse this in order to make the arrangement more logical.

Protoplasm, if regarded in its broadest sense, may be regarded, notwithstanding its indefiniteness, as the common basic substance of cell life and structure. As to its nature, no nearer approach is made to its analysis than through its physical and chemical aspects. We cannot, however, enter upon such a discussion successfully unless we review concisely the present status of "Spontaneous Generation" in its relation to the origin of life, for this must be the final thought of every listener, although it will ever be just over the border or beyond his reach. Leeuwenhoeck first saw micro-organisms in 1675. Previous to his time, and for many years after, it was believed that life could in some way be produced from dead or inert matter. Needham in 1749, announced that he had succeeded in securing the spontaneous development of life in beef broth, which had been boiled and stored in a flask. Spallanzani, in 1765, demonstrated that Needham's work was ineffective, because he had not observed proper precautions in sterilizing and handling the flasks. Spallanzani, through proper precautions, succeeded in retaining his beef tea sterile or free from germ development.

Upon opening the flasks, the beef tea soon teemed with life; in other words, this man was the first who could safely say that life was essential to the production of life or life must come from life. After one hundred and fifty years, no one has been able to gainsay Spallanzani. This statement is made guardedly, realizing that the problem still invites attacks, and not a few would demonstrate the creation of life at one fell stroke. Bastian, in his book on "The Evolution of Life" published in 1907, has not ceased his labor in the over-throw of Pasteur by actually creating micro-organisms out of saline solutions, which are prepared and introduced into tubes, sealed and subjected to a heat varying from 100° C to 130° C. After a time, he finds such forms as micrococci, vibrios, bacilli, torulae and moulds which he photographs. His summing is sufficiently characteristic of the individual and conclusive to investigators: "These views of mine as the result of oft repeated observations, are, I would submit, in accordance with the present day existence of vast multitudes of lowest organisms of all kinds on the face of the earth. No consistent explanation of their presence can be given by those who will not accept my facts." The mysteries of radium have inveigled Dr. Burke into thinking that gelatin solutions may be readily converted into life by its peculiar influence. The peculiar physical properties possessed by gelatin, egg albumen, water glass have led many a poor victim to figurative decapitation. It is too true when some new natural force becomes heralded, the public and unthinking scientific workers are a little inclined to be precocious. It would be folly for us to spend our time and energy in an effort to ascertain the value of chimerical theories and fanciful speculations. Our only safe ground is to consider those logical and developing avenues of research which may, eventually, lead to some solution, and which even at present are contributing much to fundamental knowledge.

Technical studies of protoplasm were from the first aimed at the problems of metabolism with comparatively little reference to how it came to be. Following upon the normal metabolism much attention was given to altered metabolism induced by disease and by the ingestion of substances which may have some influence upon the work of the cell. Unicellular investigations have emphasized the importance of ferments or enzymes, which are well known agents, acting as chemical stimulants. Soon, it was recognized that digestion, decomposition, putrefaction, fermentation, and perhaps many other intra- and extra-cellular phenomena are very much the same. The products resulting from the digestion of nitrogenous substances in the alimentary canal are very similar to the products of nitrogenous decomposition or putrefaction, and the digestion of carbo-hydrates and fats is practically the same as the fermentation of these bodies. Little by little, it has grown upon us that enzymes assume the rôle of inciting the various changes necessary for cellular nutrition throughout the body, thus implying, as it does, that digestion and assimilation are not confined to the intestinal canal, but are co-extensive with the cellular structures of the body. It follows that the final step is the cell, and that the cell is the unit, whether in combination with other cells to form multicellular bodies, or whether it has an independent individual existence as an organism—an entity. In the case of multi-cellular organisims it has grown to a habit to speak of specialization as if this were peculiar to complex bodies. It is equally true of micro-organisms, for do we not know that the special class of proteolytic bacteria, of lactic bacteria, of the alcohol-producing yeasts is highly specific in its functions? The correlation of these phenomena in the cell and the

vital forces centering upon the cell have given zest to investigations which are wide-reaching.

While the analysis of an enzyme is not within the grasp of man, it is well known by the specific work which it is capable of doing. We may assume that it is a molecular combination which stimulates intra- and inter-molecular changes by various means. When starch is boiled in a weak solution of acid, this polysaccharide is converted into maltose, a disaccharide. This is supposed to represent, simply and crudely, what nature does through this enzyme by hydrolysis. The changes wrought by different enzymes as starch to maltose, cane sugar to invert sugars, and fat into glycerin and fatty acids; protein into proteoses, are all looked upon as hydrolytic. There are other changes produced for which enzymes are sponsors; the change of sugar to alcohol which appears to be the splitting of the molecule, the change of alcohol into acetic acid, which means oxidation, and others, many of which are not definitely placed.

Hill says that an enzyme, maltase, which changes maltose into dextrose, may produce a change diametrically the opposite; that is, cause the synthesis of dextrose into maltose. Kastle and Leavenhart have ascertained that lipase which converts fat into fatty acids and glycerin accelerates the synthesis of fat. If this be true, whether it is the enzyme designated or some other, it is very significant from the view point of the anabolic process of the cell. Loeb says: "We understand how it happens that in times of abundant fat supply, our tissues are able to store up fat, while in times of want fat disappears from them."

In this manner, the products of fermentation, whether the results of hydrolysis, oxidation, or otherwise, have been taken as the index of the nature of the molecular structure from which they have been derived. Add to this the possibility of synthesis by fermentation, the value of this method of reasoning is not only doubled, but becomes of the greatest importance.

In the hydrolysis of proteins it is generally conceded that such groups of products respectively occur: proteoses, peptones and amido-compounds. Fischer has shown in recent years that the amino acids may quite readily combine in the form of an amide-linking; that is, two molecules of such a compound as glycocoll or amido-acetic acid by the subtraction of a molecule of water will yield glycyl-glycine. In a similar manner, many amino acids may be combined into what he calls polypeptids, which approach the nature of peptones. Leading from actual demonstration to speculation, it is easily conceived how this same process may, with some modifications, extend through peptones to proteoses, through proteoses to proteins.

Further, there is added to the knowledge of the degradation and synthesis of protein, the contributions arising from the carefully studied hexon bases which are easily split off from the proteid molecules by the action of acids. They are also formed by metabolism, enzymes, and perhaps other protoplasmic agents. Their structural nature upholds the foregoing view of Fischer by extending it and introducing other factors as oxidation.

The interesting fact that von Baeyer, in 1870, had stated that the carbohydrates of plants came by way of the carbon-dioxide of the air through the instrumentality of the chlorophyll of the plant becomes more pertinent in the light of present knowledge. Fischer has shown that formaldehyde, the supposed first product of plant synthesis from carbon-dioxide, can be easily polymerized into a hexose.

It is only a step farther, walking in a well known region, to follow the products resulting in the degradation of the carbo-hydrate and protein from their

most highly complex forms as they are broken off from the original molecules to the simple elements and compounds as hydrogen, nitrogen, carbon-dioxide and water, found in the final step. If it becomes possible, as it seems feasible, viewed from the indications named, to turn about and utilize the simple elements and compounds and build from them the more complex compounds as found in plants and animals, it will be easily seen and understood how the life forces of the cell operate. Although there are many streams to span, it does seem that there is sufficient evidence now at hand to trace the path most likely to be followed in the future in the search of the interpretations of life.

We shall now try to show how the micro-organism furnishes an excellent illustration of the way it can utilize and build up into the living substances of the cell these simpler compounds which we find in the last step of the degradation of the proteins and carbo-hydrates.

Micro-organisms are not alike, it is granted, in their requirements. Uniformity is found only after such requirements become a part of the cell substance, the protoplasm itself. Even then, they may differ sufficiently to give individuality. In reality, micro-organisms are found which can utilize the free nitrogen of the air, as discovered by Hellriegel in 1886, using it in their own metabolism, or furnishing it to a host upon which they may live. Again, there are those micro-organisms which use the free nitrogen of the air without any relation to host, however, as has been shown by Winogradsky (1893), and Beyerinck (1901). Still there are micro-organisms that will oxidize nitrogen in the form of organic matter or ammonia to nitrites or to nitrates; others reduce nitrites and nitrates to ammonia, and free nitrogen. Still again, there are those which can assimilate carbon-dioxide without possessing any chlorophyll. Along with these substances, mineral ingredients become involved and probably are a part of all life's reactions. Thus, we see the life of a micro-organism is simple; it may live upon the elements of the earth and the air, yet, out of them are constructed the most complex molecular bodies known to man. Their bodies are veritable laboratories of synthetic and analytic chemistry and physics.

Assuming that life began in the sea, and that this life is dependent upon a weak solution of the mineral constituents of the earth as found in the water, then it is easily understood how that first sea life can be simulated in micro-organisms. Lohmann makes the enumeration of microscopic sea life in one cubic meter of sea water (off the coast of Syracuse, where the sea is regarded as poor in these forms), to consist of: 2,082,740 protophyta; 325,510 protozoa; 17,415 metazoa; 785,000,000 bacteria. Johnston, who notes the above, says: "Assuming the composition of the plankton, such as represented by Lohman's tables and regarding the total surface of all planktonic organisms as equal to 1,000, he finds that the surface is shared in the following manner: Protozoa, 29; metazoa, 148; bacteria, 400; protophyta, 423, and it would appear from these figures that the protophyta (the diatomes and lower algae) play a more important part in the production of the dissolved foodstuffs than any other group of organisms in the sea. It is true that the total effect of bacteria would appear to be almost as great as that of the protophyta, and we shall see that the general effect of the metabolism of the bacteria is to convert all carbon compounds into carbon-dioxide, and all nitrogen compounds into nitric acid or even free nitrogen. It is only the protophyta among the plankton which can utilize the carbon-dioxide and nitric acid compounds, and so we see that upon these rest the

greater part of the task of elaborating the organized food-stuffs, as well as that of elaborating the dissolved food-stuffs of the sea."

It is very evident, from what Johnston says, that he is not thoroughly familiar with the different species or classes of bacteria, and he does not seem to think that it is possible that the unicellular life, as represented by micro-organisims, may be responsible for shaping the elements of earth into such form as may render them suitable for life forms beyond them. The unicellular forms can thrive upon the simplest ingredients furnished them by the sea conditions of ages ago, and it is quite possible that they can give rise to such other ingredients as would be essential for the next step in higher developments.

The machinery which is able to work up the elements into groups or radicles, groups into molecules, molecules into complexes, and, shall we say complexes into structural entity, does not necessarily require that the elements, the radicals or groups be the same. The benzene ring retains its identity through various and multitudinous changes in elements, radicals, and groups. The facial features, the individual conditions are able to be altered, but the family tie exists in the constancy of the complex which we may regard as similar to the benzene ring. Ehrlich's side chain theory has made it possible to move in various directions with some degree of fundamental truth still adherent in each manifestation. The development of anti-bodies by the living cell or central molecular complexes, their power to counteract the influence of the toxin, the production of lysins, agglutins, and other bodies which are dependent upon the living body, all indicate a remarkable power of adjustment; we say on the part of the cell, but is it not on the part of the central molecular complex or complexes, through their changing side chains? This is meagerly illustrated by the work of Nuttall, who, in his investigations with precipitins was able to establish a family connection among animals of a kindred nature. In other words, instead of using morphological methods, he was able to verify morphological methods by molecular kindredship. Among micro-organisms, this permanency of a central or molecular complex, with the possible variations occuring in its side chains or groups, is vividly brought to mind by such physical or chemical phenomena as are manifested by the chromogens in the formation of different pigments, in photogens by the production of light, in thermogens by an excessive heat accumulation, in zymogens by an exalted production of some particular enzyme, in pathogens by the formation of toxins. So far as known, in each class the necessary life functions of the cell go on in the routine manner, but all of these special functions are more or less subject to great variation. We are, therefore, disposed to throw life functions which are absolutely essential to the cell, into the body of the complex, and these secondary functions, not essential to the cell, into the same category as covered by Ehrlich's side chains.

Our attention has been centering upon the molecular structure of the cell in order to bring out its important chemical bearing upon life's development. If it were possible, in this limited discussion, to expand somewhat and include the physical factors involved in living matter and illustrate how they are applicable to unicellular life, and how they approach, in the greatest simplicity possible, the dynamic principle underlying this life, there would be, doubtless, much weight added to the contention that the summation of life's forces is within the molecular complex of the cell. It is utterly impossible, of course, to designate between physical forces and molecular or chemical forces. Heretofore, we have been concerning ourselves, however, with physical

forces as revealed by chemical technique. Osmosis is a constant physical factor to deal with in the study of micro-organisms. Heat and light are essential factors. The tropisms have interested and annoyed students of unicellular forms. Various forms of electrical energy are assuming an important rôle and will, doubtless, in the future assist much in many of the interpretations of vital forces. In other words, all those physical forces which are connected, in any sense, with life's processes will, sooner or later, have to be considered in connection with the various changes taking place in the life of the cell or in all changes that are wrought by life's processes.

Looking at the origin of life from the standpoint of the physicist, Arrhenius has conceived matter so finely divided and the surfaces so greatly increased by this division, that the power of light would be sufficiently great to project such matter from one planet through space to another planet, mathematically speaking. He even goes further and believes it possible to have micro-organisms of the smallest types convey life from one planet to another. In other words,

> "From planet to planet the life-germ flies,
> To quicken the world that retains it."

It is not incredible to imagine that micro-organisms can be so small as to yield to removal by the power of light, for it is well known that micro-organisms vary greatly in size and some are so small as to tax the capacity of the best microscopes. Ultra-microscopic forms have now entered the field, and they are largely known by the analogy of their actions to those of micro-organisms well established. These ultra-microscopic forms are usually filterable. This would indicate that their size is small. I speak of such organisms as those which cause yellow fever, horse sickness in South Africa, cattle plague, and others. While Arrhenius conceives matter mechanically divided so as to respond to the energy of light, in the case of micro-organisms he assumes that there are forms so small as to correspond in size with the possible physical divisions. By his views, however, Arrhenius gets no nearer solution of the origin of life, even if he attempts to transfer life's generation from planet to planet, for he must, eventually, become tired in chasing the bag of gold under the rainbow.

We must now leave the molecular consideration of the cell, in part, and undertake for a time to study the cytology of the micro-organisms as viewed from its structural standpoint. This transition can be best accomplished in the words of Wilson, who says "Precisely as the various organs and tissues are the seat of special activities leading to the formation and characteristic transformation of specific substances—as for instance, hemoglobin is characteristic of the red corpuscles, the chlorophyll of the assimilating tissues of the plant—so in the cell, the various morphological regions are areas of specific chemical activities and are characterized by the presence of corresponding substances. The morphological differentiation of cell-organs is, therefore, in a way, the visible expression of underlying chemical specialization, and these are, in the last analysis, reducible to divisions of metabolic action." In other words, there appears to be a direct relation existing between the chemical, physical and structural features of the cell.

The nutrition of unicellular organisms leads to many anomalies which will help us to understand the direct bearing of nutrition or metabolism upon its structure. In the study of micro-organisms, descriptions of morphological features must be based upon the nutrition furnished, otherwise.

the description would be considered faulty. It does not require much time or many generations to induce structural changes in cells; even reaching some of the more intimate and essential organs involved. The anthrax micro-organisms become sporeless; the tubercle bacillus may perhaps furnish branched forms; the pleomorphic appearances of the acetic bacteria are well known; the hay bacillus may be lengthened or shortened, all through the influence of the nutrients furnished. Some of these changes appear to be more or less permanent and the exact limits of the changes cannot be placed. It is quite a common feeling that micro-organisms may be easily led into one channel or the other, but to what extent is still an unknown factor. The subjects of variation and mutation are no less common or striking with micro-organisms than with the species higher in the order of life forms.

Besides the influence of nutrition, which seems to have a marked effect upon the structure, other factors, as the air, temperature, light are equally prominent in shaping the form of a single celled organism. Owing to this fact, it is not so far removed from actual evidence to state that the structural or morphological features find their directive in the molecular complex of the living form. Again I quote from Wilson: "When we consider the analogy between the centrosome and the basi-chromatin granules, when we recall the evidence that the latter graduates into the oxy-chromatin granules, and these, in turn, into the cyto-microsomes, we must admit that Brücke's cautious suggestion that the whole cell might be a congeries of cell propogating units of a lower order is today not entirely without support of facts." It would seem that slow, yet persistently progressive variation is quite within the power of cell life, and that cataclysms of different degrees may give rise to variations and mutations of corresponding extent.

Studying the micro-organism in the light of the structure of other cells, it is found that there exists a great similarity. The chromatin granules which may or may not be regarded as independent parts, are found distributed through the protoplasm of most micro-organisms. These may be identical with the chromatin which belongs in the formation of the spireme. Swellengrebel points out a spiral in Bacillus maximus buccalis extending along the long axis of the cell. It is found in young and adult cells. This filament possesses an active affinity for nuclear colors, and in composition is closely allied to chromatin. The chromatic portions of this filament corresponds to linin. From this structure appears to arise a chromosome which, eventually, divides into two daughter chromosomes, each in turn entering into the formation of a daughter cell. This work of Swellengrebel brings one to the belief that there exists karyokinesis in the bacterial cell. Mencl has claimed this mitotic division in the case of Bacillus of periplaneta orientalis. Schaudann believed that he was able to demonstrate the rudiments of sexuality in bacillus bütschlii and would distinguish it from the ordinary vegetative division. This same author has studied in detail the different stages of development in the flagellates, notably, trypanosoma, and has endeavored to demonstrate a close relation with the stages of development in the spirochaete. In this, Novy does not agree, and indicates clearly that there may exist some confusion in the description of species considered. For our purpose, it is plainly evident that there is sufficient evidence on the one hand, and sufficient ignorance on the other, to make it plausible that there is a general method of cell division running through the world of micro-organisms, modified in one way and another in the individual species, which is very similar to that found in all living cells.

If environmental conditions, such as nutrition, light, heat, temperature,

and other factors, can, little by little, alter the molecular complexes of the cell and these, in turn, change its structural features, it follows that unicellular organisms may, within limitations, become so varied as to produce new variations, new species, and perhaps, new classes. Eigenmann, in his study of adaptation, has been able to follow changes in fishes which would lead him to believe that the salt water fish may become a fresh-water fish, and that fresh-water fish may adapt themselves even to salt water conditions, and that fish in caves may be influenced by the absence of light to such an extent as to alter their visual organs. To do this, much time is required. Unicellular life responds quickly to its environmental conditions: only a a few generations are required to produce striking results. Nitrogen-gathering bacteria appear in one form in some artificial media, and in another in the nodule itself. The tubercle bacillus exists in the form of typus humanus in man, typus bovinus in cattle, typus avius in fowls, with all forms between, according to Fibiger, Bang, and others. The micro-organism of glanders loses its virulence in two or three generations when grown in artificial media, but if passed through an animal frequently, its virulence is maintained. A chromogen may lose its pigment completely in one generation, but may recover it in another. If we consider the micro-organisms of the sea, we can understand how they can, little by little, adapt themselves from salt to fresh conditions and to different densities of brine. There are those organisms which are easily influenced by salt, and those which grow readily in a twenty per cent solution. In the sea, too, there may be found those which find themselves in the bodies of higher plants or animals, and, after a time, may find it possible to produce pathological conditions; they may escape from the plant or animal, find themselves stranded under entirely new conditions, thus losing all of their former power to produce pathogenic effects. It is not stretching the imagination too much to see the sea micro-organisms stranded in bogs, where they soon adapt themselves to their surroundings, or they may even accommodate themselves to droughts. Briefly, we can see micro-organisms moving landward, seaward, becoming pathogens,chromogens, photogens, zymogens, and can see them also moving in an opposite direction. There is almost sufficient evidence to establish such a view as a fact, and yet, it would not be safe at the present time to accept such a general statement. The many individual cases of change and variation, of adaptation or adjustment among micro-organisms without any established limitations must impress every investigator of the great possibilities open for more extensive, as well as intensive, work along these lines.

We are disposed to believe that functioning is gradually adjustable within the limits placed by our natural environments, and that variations in morphology of micro-organisms is a result of variation in functioning. If natural processes are finite, then development becomes finite; if infinite, then development becomes infinite; whether finite or infinite, is now beyond the finite mind.

It is, therefore, significant that classifications upon which we are dependent are exceedingly superficial, but, perhaps the best available at the present time. In bacteriology, physiological classification has progressed to some extent, but it must be exceedingly limited, because of ignorance. When it becomes possible to deal with the molecular complexes of the body, and the many physical forces involved then will appear a more wholesome classification—one that is more stable and better unified.

Man, as a rule, is not content to believe that he represents the climax of possible living forms; he likes to think of the indestructibility of matter,

and of course, since living forms are manufactured out of indestructible matter, he would like to think of indestructible or immortal living matter or bodies, notwithstanding the seeming difficulties. In the beginnings of life at one time, he stopped with multi-cellular organisms, because these he knew, the unicellular organisms, he did not know. With the acquirement of a knowledge of unicellular life, he stopped for a short time; then he began to center upon the nucleus, the nucleolus, and other anatomical structures. Following this stage of development, has come the history of the atom, the molecule, the molecular complexes, with other accompanying elemental physical properties or forces. In this bewildering world, the minds of many scientists are centering. From such studies which enter into the intimate nature of the cell, we shall learn much, but when we look from effect to cause, from absolute effect to absolute cause, our minds stretch out ad infinitum and ask: "What then?" This has been out of our province to discuss, but can any scientist fail to recognize his weakness to cope with such a problem in our present light? Can he still be a scientist and pretend to reach even a tentative conclusion concerning the ultimate cause of life? He cannot do justice to the world, as a scientist, if, with the facts at hand, he attempts to promulgate beliefs which are as ill-founded as those which he would sweep away. He ceases to be a scientist when he jumps from the natural to supernatural; when he takes up the cudgels of dogma to fight dogma; when he convinces himself that the only world is his world, which is an atom as compared with the universe; and, when he would measure life by professionalism, provincialism, and individualism. Let the scientist concern himself with the unrolling of nature to the people who are not so fortunate as he, that it may become more real, and more majestic to him who would appreciate the magnificence of the Handiwork of the Absolute Cause. Nowhere have we a better illustration of such a course as a guide for scientists than in the life and work of Darwin:—a man so simple, so unpretentious, so unselfish, so generous, so very truthful, so diligent in work—all for one purpose—to reveal that Handiwork.

A CONTRIBUTION TO THE THEORY OF ORTHOGENESIS.[1]

DR. ALEXANDER G. RUTHVEN.

Several reasons have been given why biological discussion has, for a number of years, ceased to center about the fact of evolution and is now chiefly concerned with the factors, for such is evidently the case: the principal aim of modern biological researches is apparently to throw light upon the question of method. It is now a part of common knowledge that Darwin considered the natural selection of fluctuating variations to be the principal factor in evolution, and some of his successors have gone so far as to see in it a sufficient one; but, while few biologists will probably be disposed to deny that natural selection is an efficient factor in evolution, there seems to be now on hand a sufficient body of data to show that it is far from being the only one. Among other methods[2] that have been emphasized, mutation and orthogenesis may be mentioned, each of which has its adherents, and it is the last named of these that seems to be the principal one concerned in the evolution of a group of snakes that I have recently monographed—the genus Thamnophis (the garter-snakes).[3]

I will briefly summarize the conditions that prevail in this group:

1. The genus Thamnophis consists of four groups of closely related forms, each group ranging both northward and southward from the Mexican plateau (which is their center of dispersal) into North and Middle America.

2. Each group consists of a series of forms, the ranges of which adjoin and correspond to different geographical regions.

3. The forms of the same group may intergrade or not, but in either case they come in contact where the geographic conditions with which they are associated meet, and the areas of transition in characters correspond to the areas of intermediate environmental conditions. When the forms intergrade the transition in characters takes place gradually in the intermediate region, and where there is apparently no intergrading at present the two forms become most like each other in this region, there being no abrupt changes in characters between two directly related forms.

4. Each group tends to become progressively more dwarfed away from the Mexican plateau, each form usually being more dwarfed than its neighbor toward the center of origin, and less so than the representative whose range adjoins it on the side away from the center.

5. The relative size is correlated with the number of labials and rows of body scales, and these two characters—size and scutellation—constitute the only apparent specific differences, except in the few cases where they are accompanied by differences in color or relative tail-length.

6. The amount of dwarfing is not associated with particular geographic regions, but the scutellation and relative size of any form is that of its immediate ancestor plus the dwarfing which it has itself undergone. Thus a dwarf form of one group frequently occurs in the same region with a much

[1]Reprinted from the American Naturalist, XLIII, No. 511.

[2]I mention only these three (selection, mutation and orthogenesis) as they appear to me to be the only ones that can be considered to have been dominant methods in the evolution of the forms in the genus that constitutes the basis of this discussion.

[3]Ruthven, Alexander G., "Variations and Genetic Relationships of the Garter-snakes," Bull. 61, U. S. Nat. Museum.

less dwarfed representative of another group, the difference in relative size being due to differences in the number of forms between the one in question and the center of origin.

7. The variations in the characters of each form fluctuate about a mean, and the transition in characters between the different forms is brought about by a gradual variation of the average type.

Students of evolution problems will recognize in this summary (*a*) the old story of the association of different forms with different environmental conditions, (*b*) the so-called definite or determinate evolution, and (*c*) that the phylogenetic variations are gradual.

It has long been noted that, among animals of the same group, the different forms are generally associated with different environmental conditions. In some cases it seems that these forms may occupy different habitats in the same environment, but in by far the greater number of instances, at least among terrestrial animals, directly related forms inhabit different but neighboring, geographic areas. That there is some connection between the differentiation of such a group and the diversities of the region it occupies has usually been assumed; at least it is a fact that must be considered in any explanation of evolution. It is explained by natural selection on the assumption that the different conditions in the two regions demand different adaptations on the part of the organism, but this explanation will apparently not hold in the case of the garter-snakes, for there is certainly no advantage in dwarfing *per se*. It might be assumed (and it would be pure assumption) that this trait is correlated with unperceived adaptative characters, but this would seemingly be trying harder to save the theory of natural selection than to explain the facts. I have pointed out that there is no relation between the amount of dwarfing and particular habitats, but that forms (belonging to different groups) of quite diverse scutellation may occupy the same region. Apparently the conditions in each region do not call for a particular size (as would, it seems to me, be approximately the case if the struggle for existence in each habitat required that the forms become dwarfed), but only act to modify to some extent the invading form, the relative size of the latter being determined as much by the modifications which the group has previously undergone as by those to which the particular form has been subjected.

I believe that these objections to the operation of selection in the evolution of these forms also argue against DeVries's mutation theory as an explanation, for, while it is easily conceived that mutations may have arisen within the limits of fluctuating variation in each case, we must also assume that the new form pushed into the new environment, or at least now occupies it to the exclusion of immediately related forms, because better fitted for it, which does not seem to be the case. What seems to have actually taken place is that as each group pushed out from the center of origin it became modified each time it encountered a new region of environmental conditions, not by the selection of forms better adapted to the new conditions, but by the modification of the entire section that invaded the new region. This may be tested more thoroughly by an examination of the method of evolution.

Perhaps the most striking characteristic of this genus is the manner in which evolution has taken place along definite lines. Although the forms frequently have other distinctive characters, they nearly all have this in common that they are more dwarfed than the form from which they have been derived, and there is no case in the genus where a form is larger than its neighbor toward the center of origin. The history of each group has thus

been one of progressive dwarfing as it departed from the center of dispersal.

It is too often overlooked by students of evolution that natural selection can cause directed evolution (orthoselection); for in order that it may do so it is only necessary that there be an accruing advantage in the increased development of a character. The characters must thus be utilitarian, however, which is apparently not true in this case. Moreover, it would certainly be taxing the theory to make it account for the continued development in the same direction in the four groups, when one considers the great variety of conditions with which they are associated. To explain this definite development on the basis of orthoselection it would be necessary to adopt the point of view that each form in each group found it of advantage in the struggle for existence in its particular environment to become more dwarfed than its immediate ancestor, which is to my mind unthinkable when one considers that we have in this genus four groups that push out in all directions from the center of origin, into desert, grassland and forest regions, in the tropical and temperate zones, and yet in every case the modifications associated with each region are practically of the same nature and non-adaptive. We meet the same difficulties if we attempt to apply the mutation theory to explain this definite evolution, for, while De Vries's mutants arise suddenly and are definite steps in new directions, he states in regard to the accumulation of characters:[4]

> It is not by mere chance that the variations move in the required direction. They do go, according to Darwin's view, in all directions, or at least in many. If these include the useful ones, and if this is repeated a number of times, cumulation is possible; if not, there is simply no progression, and its type remains stable through the ages.

It seems from this that in order to explain the evolution of a group by a series of modifications more or less similar in kind the mutation theory of De Vries is forced to fall back upon natural selection. If I have rightly interpreted the conditions, I believe that natural selection, with or without the assistance of the mutation theory, fails as an explanation of the definite evolution of this genus, and that we have here an example of true orthogenesis, *i. e.*, progressive modifications in each group without the aid of natural selection.

The nature of the variations is very interesting in several ways, and throws further light on the problem, for, although one must be cautious of forming conclusions on this subject without the controlling evidence of experimentation, certain general relations seem to be apparent.

I have stated that the variations in each form fluctuate about a mean, but that this mean varies, approaching in the intermediate region that which characterizes the next form on its line of descent. That the different forms also originated in this way is shown in the numerous instances where they actually intergrade. This is essentially the idea of mutation (in the sense of Waagen and Scott) or "phylogenetic variations," which is not to be distinguished from individual variation by any character of quality or quantity, but by the fact that it pursues a determinate direction by the gradual shifting of the normal type. Conn[5] states that:

> It should be noticed that these considerations in regard to variations along definite lines have less significance in connection with such characters as can be supposed to advance by general averages. Some organs have been advancing in definite directions for long generations, but if the advance consists of an increase or decrease in size of the organs there is not needed any law of determinate variation to explain the matter. If it be an advantage to have an organ increase in size, and if variations in this organ occur around an average type, then without any necessity of supposing a special law directing variations, we can understand how natural selection will continue to increase the size of the organ in question.

All this is very true, for it is only orthoselection working on the average type, but as selection seems to be debarred in this case, the characters being

[4]De Vries, H., "Species and Varieties, Their Origin by Mutation," p. 572.
[5]Conn, H. W., "The Method of Evolution," p. 146.

non-utilitarian, we apparently have in the garter-snakes a case of evolution along fixed lines as the result of definite variation. Even if we could admit the selection of fluctuating variations as the dominant factor in the evolution of these forms, we should encounter the additional difficulty that it (selection) is apparently unable to create a new species, the form slipping back to the original condition when the selection ceases. The nature of the variations also seems to me to debar De Vries's theory of mutations as a possible explanation, for, according to De Vries, the specific changes are sudden and fixed, the new race appearing fully formed, which is certainly not the case in these snakes, unless we consider the new race as having been formed by small successive mutations of the same kind, which would, if I understand him rightly, be contrary to De Vries's idea of mutations, for he says that they "take place so far as experience goes without definite direction." We have apparently in these snakes an example of definite but gradual variation, in that there is in each group a gradual development of forms along a fixed path, without the aid of natural selection.

A theory that accounts for the definite evolution of this genus without the aid of selection is that there has been in each group a gradual modification of the forms under the influence of the environment. The determinate variation of the average type, the close association of the forms with different geographic regions and the consequent correspondence of areas of transition in characters with intermediate geographical conditions, would seem to render this conclusion unavoidable, if, as seems evident, selection is not operative here. It should be noted, however, that, while the evolution of the genus has been distinctly orthogenetic and associated with the environment, it does not appear that the latter has, as has often been supposed by adherents of this theory, a specific effect. This would be difficult to determine if we were dealing with one group, for example one that pushed northward from the Mexican plateau, for here there would be an increasing difference in climatic conditions associated with accumulated modifications, between the range occupied by the form at the center and that of the most outlying species. But when all four groups are considered it is seen that the same modifications appear whether the group is pushing into the tropic or temperate regions, or into deserts, semi-arid plains, or humid forests, and it is difficult to conceive of environmental conditions common to all of the regions occupied by these snakes that would exert such a specific effect upon them. It seems rather that throughout the genus the germ cells have such a restricted number of potential responses that the different groups have tended to vary in the same direction (homoplasy) under the influence of the environments which have been encountered; that is to say, the similarity of the response is conditioned by the constitution of the animal, the environment only acting as a stimulus upon the germ cells.

This theory would seem to satisfactorily explain why some directly related forms intergrade while others do not, for if infertility is in proportion to physiological diversity, as Darwin held, it is quite evident that as the new form produced as a group pushes into a new region becomes more or less modified, it will also probably become physiologically different from the parent stock and be more or less unable to cross back. This is essentially Eimer's Genepistasis, or Entwicklungstillstand, the standing still of certain forms at definite stages in development while others continue. But it should be noted in this case that the forms that progress each time are always associated with new geographic regions, and do not occur, as Eimer holds that they can, in the same region with the parent stock.

In conclusion I would like to point out that the purpose of this paper is to describe the method of evolution in the genus Thamnophis rather than to discuss the cause of the variations. It is evident that the suggested relation between the action of the environment and the nature of the response of the organism can only be tested by experimentation. I may add further that the interpretation offered of the conditions in this genus depends upon whether or not the relationships of the forms and the lines of development are as outlined. In pursuing work of this kind it soon becomes apparent that the relationships of any form can only be determined with certainty when the conditions that prevail throughout the genus have been examined carefully, and, conversely, that erroneous ideas of relationships are very liable to result from incomplete knowledge of the course of evolution in the group, so that it is very hazardous to select a few forms of a genus and endeavor to discover the laws governing their development. An illustration can be drawn from this genus: *Butleri*, which lies entirely within the range of *sirtalis*, may, so far as its characters go, easily be conceived to have been derived from the latter, and, if so, a different theory of the factors involved in its evolution must be sought to explain its origin. That it has more probably been developed from *radix* by dwarfing only becomes relatively certain when the lines of evolution in the genus have been worked out. This should discourage attempts to adduce as evidence for or against any theory the relationships of particular forms before the genus has been studied as a whole, and the general lines of development determined.

AMERICAN PALEONTOLOGY AND NEO-LAMARCKISM.

E. C. Case.

The terms Neo-Lamarckism and Neo-Lamarckian were first used by Prof. A. A. Packard in 1885 (Introduction to the Standard Natural History.) The foundations of the school were laid before Darwins time in the writings of Lamarck.

He taught—First, that in animals which have not passed the limit of their development the continued use of an organ increases its size and power and that conversely the lack of use leads to deterioration. Second, that the condition or character thus acquired is transmitted by heredity to its offspring. Here we have the *origin* of a variation. Darwin's great work added the factor lacking in Lamarckism and brought a vague hypothesis to the condition of a working principle by elaborating his conception of a Natural Selection.

It is generally conceded today that Natural Selection can not *originate* a variation, the basis of all evolution; but is the dominant factor in the *preservation* of variations once originated and their development into species.

Lester Ward in an address before the Biological Society of Washington, in 1891 makes the union of these two principles the basis of the Neo-Lamarckian School. He said, "Neo-Lamarckism, as I understand it, while recognizing natural selection as the more prominent of the two agencies, also recognizes that the increments of change impressed on individuals during their lifetime or brought about by individual efforts or habits are also perpetuated in some measure through heredity and form an important factor in the general process of organic development."

As will be shown, the present content of the Neo-Lamarckian idea is not compassed by this definition though it is a clear outgrowth therefrom.

Neo-Lamarckism has received a considerable, if not its chief, body of support from the American paleontologists. This has rather been due the conditions which have presented to them a large body of evidence in a peculiar way than to the presence of any dominant leader of the movement. The paleontologists of America, and especially those working among vertebrates have been especially fortunate in that they have found almost at their doors large numbers of beautifully preserved fossils representing long phylogenetic lines and preserved in undisturbed strata, rendering the sequence of the deposition certain. European workers have not failed in their appreciation of the claims of this school but have rather lacked the same opportunities.

I take it to be a most significant fact that workers along such divergent lines as fossil vertebrates, fossil invertebrates and fossil leaves, but having in common the opportunity to view long phylogenetic lines should come to a common conclusion. The paleontologist does not have the chance to view large numbers of individuals and so fails to have impressed upon him the frequency of variation; also it is the exception that he can trace the individual variations which are caused by geographical changes, but to compensate for this his material affords him surpassing opportunity for a just appreciation of the influence of time and heredity. The nature of the evidence has in a manner forced the conclusions of the paleontologist and has at the same time

armed him for a defence of his conclusions based largely upon deduction and permitted him to leave speculation in the background.

It is always a thankless task to call the roll and appraise the results of any body of workers, but certain men have stood out so prominently in the development of the Neo-Lamarckian school that we may name them without fear of contradiction. Cope, Ryder, Scott and Osborn among the vertebrate paleontologists, Dall and Hyatt among workers on invertebrates and Lester Ward of the paleobotanists; the work of these men may be taken as epitomizing the growth of Neo-Lamarckism in America. Of these Cope, Ryder, Dall and Hyatt may be regarded as the founders of the school. In 1886, Hyatt read his paper "On the parallelism between the different stages of life in the individual and those of the entire group of the Molluscan order Tetrabranchiata" in 1880 he defined his ideas more clearly in two papers "Upon the effects of gravity upon the shells of animals" and "The genesis of Tertiary species of Planorbis at Steinheim." In 1890 Dall published his paper on the "Dynamic Influences in Evolution." In 1871 appeared Ryders paper "On the laws of digital reduction" and in 1879 another "On the mechanical genesis of tooth forms," other papers from this author appeared at intervals until 1890 upon similar themes. Copes Origin of the fittest appeared in 1887 and the Primary Factors of Evolution in 1896. These books were in large part republications of essays printed at earlier dates.

These papers represent a distinct stage in the development of the Neo-Lamarckian school for they insist on the *origin* of variations from the effect of strains set up by the environment or by the effort of the individual and on the preservation of these variations by natural selection. This is, perhaps, Neo-Lamarckism in its purest phase.

The continued studies of long phylogenetic lines such as the labors of the American paleontologists were perfecting led to the recognition of the fact that Neo-Lamarckism as defined above was not competent to answer all questions which arose and so there has been a gradual development of the present phase of the theory entertained by the so called American School.

Osborn in an address before the American Society of Naturalists in New Haven in 1906 described what he called the *four inseparable factors* in evolution—Ontogeny, Heredity, Environment and Selection. He expressed these in the formula O×H×E×S in which the × sign may be read "influenced by and influencing." We may review Osborns paper as a convenient way of introducing the new phase of Neo-Lamarckism. S need not be discussed, for according to the Neo-Lamarckian school it can not be admitted as a factor having to do with the *origin* of variations, though nearly *all powerful* in their preservation.

The Buffonian factor of evolution may be expressed in the formula by E×o×h×s. Emphasizing the predominant effect of the environment, Dall in his paper on the Dynamic Influences of Environment said: "The environment stands in relation to the individual as the hammer and the anvil to the blacksmiths hot iron. The organism suffers during its entire existence a continuous series of mechanical impacts, none the less real because invisible." As Merriam said these are bold words but weighty and well worth considering.

The Lamarckian factor may be represented by the formula, O×h×e×s, *i. e.* The development of a character *during the life of the individual* and the establishment of this character by heredity.

But Lamarckism has failed to answer several questions which have been proposed,

1. How can a character acquired during senility be transmitted to offspring which are born before the character is acquired, and still the offspring develop the senile characters of the parent.

2. Neo-Darwinians have formulated the following test for the transmission of acquired characters. If a form is placed in a new environment it will frequently develop new characters, but if the offspring even of the third or fourth generation, which has the new characters, be transferred back to the original environment the characters assumed during the changed condition will disappear. The acquired characters were not fixed. Lamarckism has not yet pointed to an undoubted case of the fixity of acquired characters.

3. Experimenters can not say whether the characters which appear under changed conditions are new or whether they are reversions to a previous condition when the animals lived in an environment similar to the one in which it is placed by the experimenter.

4. Lamarckism can not explain the growth and development or rudimentary structures. It cannot account for the development of characters which are useless.

Now having rejected other explanations what has the Neo-Lamarckian to offer instead. I fear that he comes with little but a wealth of observation and a receptive mind. He has observed long phyla in which characters appear, not fortuitously, so far as we can see, but *determinately*, in the place where they will *at some future stage* do the most good to the animal. He has observed such characters or structures appear as useless rudiments, persist as such during the life of the individual and gradually develop to usefulness during the life of the race. He has observed these rudiments rise and develop *entirely removed from the influence of the environment.* He feels that he must minimize the effect of both Ontogeny and Environment in the formula proposed and there is only left the effect of heredity (H) *and an X.* For Selection is a constant factor in all.

Let us consider the strongest case which the Neo-Lamarckian has to offer; that of the molar teeth of the mammals.

1. Teeth do not appear as developing organs exposed to the influence of the environment but attain full perfection in the individual beneath the gum and only break through to reach any contact with the environment when fully formed.

2. Immediately upon exposure to the environment the contract works to the detriment of the tooth because the wear continuously lessens the efficiency of the tooth.

No one can see the *direct effect* of either a Buffonian or a Lamarckian factor here. The tooth is developed free from any contact with the environment and the effects of use are distinctly to reduce the value of the structures. The inheritance of a retrograde character such as this last would not afford material for selection.

Paleontologists have worked out the plan and order of the appearance of the cusps on the molar teeth of the mammals and brought the law to such perfection that it has stood the final test of successful prophecy. This is *definite evolution* such as was foreshadowed by the founders of the Neo-Lamarckian school when Hyat in 1866 wrote concerning the Cephalopods. "In other words there is an increasing concentration of the adult characters in the young of higher species and a consequent displacement of embryonic features which had themselves also appeared previously to the adult period of still lower forms," and Cope in the same year wrote "The presence of a rudimental condition, or the absence of a given generic character can be

accounted for on the hypothesis of a greater rapidity of development in the individuals of the species of the extreme type, such stimulus being more and more vigorous in the individuals of the type as we advance toward the same, or by a reversed impulse of development, where the extreme is characterized by the absence or 'mutilation' of characters."

The factor emphasized by these writers and their fellow workers is little more than pure Lamarckism. Cope, Ryder, Hyatt, Dall all insisted on the development of structures due to strains induced by the actions of the individuals or due to outside influences, but as shown in the quotations given they had something of the ideas which were later developed.

In the case of the molar teeth a structure rises beyond the influence of environment, devoid of use, and is subject to a wear during ontogeny which reduces its value and yet *it reappears in the offspring strengthened and advancing. This process continues apart from and even in despite of the influence of environment.* This is the crux of the whole thing. A structure rises in a region entirely protected from the action of the environment, and despite a repressive action during the ontogeny of the individual the structure develops to a higher state of usefulness in the phylogeny of the race. This is the fact which Nageli would explain by his "internal perfecting principle," Eimer by Orthogenesis, Waagen and Scott by Mutation, Osborn by Definite Variation, Rectigradation and Homoplasy. Each of these is but a minor variant of a common idea.

Nageli's idea of an Internal Perfecting Principle we may place behind us as an almost too frank confession of ignorance and a premature confession of inability to arrive at a rational conclusion.

Eimer's Orthogenesis has been discussed by another this afternoon. The name indicates its relation to the other theories.

Scott in his paper on Variation and Mutation in 1894 discusses Bateson's great work on the materials for the study of variation and strikingly contrasts Bateson's conclusions drawn from the examples he cites with the conclusions that have been drawn from long phyletic series. He shows that while individual variation may be almost in any direction and may result from the addition as well as the reduction of parts, in phyletic series no case has been observed where there has been other than a *decrease* in the number of parts. This is particularly evident in the development of teeth and of foot structures. Scott concludes that phyla show *an orderly advance in variation* toward a definite end. This advance is shown in the morphological mean of the species, or if you please, in the normal individuals. There may be all sorts of minor variations around this but it is the individuals in the line of orderly advance which persist. Scott illustrates this advance as follows: "This mode of viewing the facts may be illustrated by an analogy. The path of a cyclonic storm is determined by the path of the storm center around which the winds circulate, blowing in every direction. These circulating winds would represent the variations which occur at every stage in the history of the phylum, while the course of the storm center would represent the phylogenetic change, or mutation. Thus the cycles of variation tend to repeat themselves, though the center around which they revolve has a course of its own, dependent, not on the accumulation of those winds which happen to be blowing in the right direction, but upon factors of much greater significance." One or two other quotations will make clear his idea. "Indeed, the most striking fact about any well established phylum *is the directness of its advance towards its final goal*, however greatly or in however many directions it may be varying at any or all stages of its history.

This does not imply that the line may not give off side branches or may not bifurcate into two lines. But while we represent such ramifications by branching lines in our genealogical trees, it must not be forgotten that each of these branches, considered only with reference to itself, forms a direct line from ancestor to descendant." Again "The *direct, unswerving way* in which development proceeds, however slowly, is *not* suggestive of many trials, and failures in all directions save one." And lastly these facts at least suggest the possibility that individual variations are not incipient species, but that the causes of the transformation lie deeper and act with considerable uniformity upon large numbers of individuals. It may, perhaps, be the outcome of future investigation that, while variations are due to the union of changing hereditary tendencies, mutations are the effect of dynamical agencies acting for long in a uniform way and the results controlled by natural selection." This last may be taken almost as a definition of Neo-Lamarckism as it now stands. Concerning this idea of mutation which he adapts from Waagen, Scott says "Another very obvious objection to the mode of evolution here suggested lies in its apparent appeal to a mystical directing force which makes for differentiation or simplification, as the case may be, the nature of which we can hardly hope to learn. Such mysterious forces are only to be admitted when there is absolutely no escape from them. The notion of a directing factor in evolution may be altogether illusory and yet it is difficult to shake it off. It is continually appearing in one form or another in the writings of those who do not explicitly acknowledge it and are perhaps hardly conscious that their views imply it. The later theories of Weismann necessitate its assumption in some shape. But this force may after all be only the expression of some general law which has not been formulated, but if it is real, we shall not advance our science by shutting our eyes to it."

Osborn has contributed a considerable number of most valuable essays all directed toward the emphasis of an *unknown factor in evolution*. He says "If Lamarckism fails to explain the origin of variation then we must seek for an unknown factor." In another place he says "The main trend of evolution is determined not by the transmission of the full adaptive modifications themselves as Lamarck supposed, but by the *disposition* to adaptive atrophy or hypertrophy at certain points."

In his paper on Homoplasy as a Law of Latent or Potentical Homology Osborn says "cases of independent evolution of apparently homologous organs I recently proposed to signify as potential or latent homology borrowing the term latent from Galton as indicating a germinal rather than a patent or adult character, and the physical term potential as expressing the innate power or capacity to develop certain organs." This idea he later found to be covered almost exactly by Lankasters term HOMOPLASY and so he adopted that term. On page 265 of the same article he writes "As observed in the evolution of the teeth, especially, homoplasy appears to be of very great importance, not on the technical ground of uniformity in nomenclature, but because it seems to coincide with the principle of definite or determinate evolution, a principle which may be of wider application. On page 267 of the same article we have with regard to the molar teeth "I have pointed out * * the significant fact that new cusps of the molar teeth do not appear at random, but at certain definite points; that they are at first so minute that they can barely be perceived, so that it is difficult to theoretically assign them a survival value in the struggle for existence; that the Lamarckian explanation is the only one which can be offered; I laid the chief stress, however, not upon the mechanical explanation, but upon *definite or deter-*

minate origin and this has been confirmed by the subsequent study of thousands of teeth in different orders of mammals. The still more significant fact that this definite and determinate evolution was proceeding independently in a great many different families of mammals did not at the time impress itself so strongly on my mind.

If molar teeth are found independently evolving in exactly similar ways in such remote parts of the world as Switzerland, Wyoming and Patagonia it is obvious that the process is not governed by chance but represents the operation of some similar or uniform law deduced from the four following considerations:

Firstly, the teeth differ from all other tissues and organs of the body in being preformed, beneath the gum. Unlike all other organs they are not modified, improved or rendered more adaptive by use; on the contrary, after the first stage of wear, the longer they are used the more useless they become. Thus, new structures in the teeth do not first appear as *modifications* (as distinguished from congenital variations) in the course of the life, as is so often if not invariably the case with new structures in the skeleton. New cusps, folds, crests, and styles are invariably congenital. Thus of all organs in the body the teeth most exclusively and purely represent the current of the stirp, germinal or constitutional evolution.

The other three considerations do not concern directly the matter in hand.

In 1905 Osborn proposed the term Rectigradation to express what he had previously expressed as definite variation. "It embraces changes which many writers have described as orthogenetic, under the supposed law of direct change (usually in an adaptive direction) which is termed orthogenesis; these probably are the mutations of Waagen." I cite these to show how close are the various ideas.

And finally we have Osborn's search for the "unknown factor in evolution." In 1891 he wrote "disprove the Lamarckian principle and we must assume that there is some third factor in evolution of which we are ignorant." In 1908 he reasserts his position with regard to the law of rectigradation. "The law of gradual change in the origin of single characters, measurable at long intervals of time, rests on a vast number of observations," but he is still at sea as to the cause of the change.

And there Neo-Lamarckism stands today. Starting with Cope's and Ryder's idea of the development of new structures through strains and stresses set up in the organism and the preservation of such characters by natural selection it has developed beyond that idea. It admits the origin of characters by use and disuse, directly or *indirectly* (for even the cusps of molar teeth appear at points of the greatest contact or strain); it admits the possibility of the origin of new characters per saltum (Mutation of De Vries) but beyond all this it demands the recognition of a factor, not yet clearly understood, which governs the origin and development of hereditary characters without the influence of the environment and even in seeming despite of it. Its chief exponents demand the recognition of a factor which will cause the development of an organism along a definite and perhaps, in some degree, predetermined line through and over difficulties which are by any other theory inexplicable.

MUTUAL INTERACTION OF PLANT ROOTS.

J. B. Dandeno.

The experiments here described are a continuation of certain laboratory cultures made during 1907 and previously, and published in the tenth report of the Michigan Academy of Science. These experiments are also in a sense preliminary to a further investigation along the same line, having as the chief aim in view the study of the effects of the roots of certain economic plants the one upon the other. In dealing with such a matter as this, where there may be such a variety of influences and conditions, it is advisable to experiment very extensively and to be cautious and conservative about conclusions and theories relating to them. These experiments are, therefore, by no means considered conclusive; and the results are here published simply as so much further data relating to the one subject indicated in the title above.

Several years ago when working on a farm, one of the common jobs during the month of June was cutting Canada thistles in the grain fields before the grain had headed out, and at a time when the thistles were taller than the grain. At this time it was frequently observed that the patches of thistles were growing in the best patches of grain. No explanation was ever offered for this seemingly peculiar phenomenon excepting that it was thought thistles would not grow on the poorer land, consequently they were found only on the most fertile portions of the field. In these fertile spots the grain crop, would, of course, be expected to surpass the rest. But these explanations never seemed satisfactory.

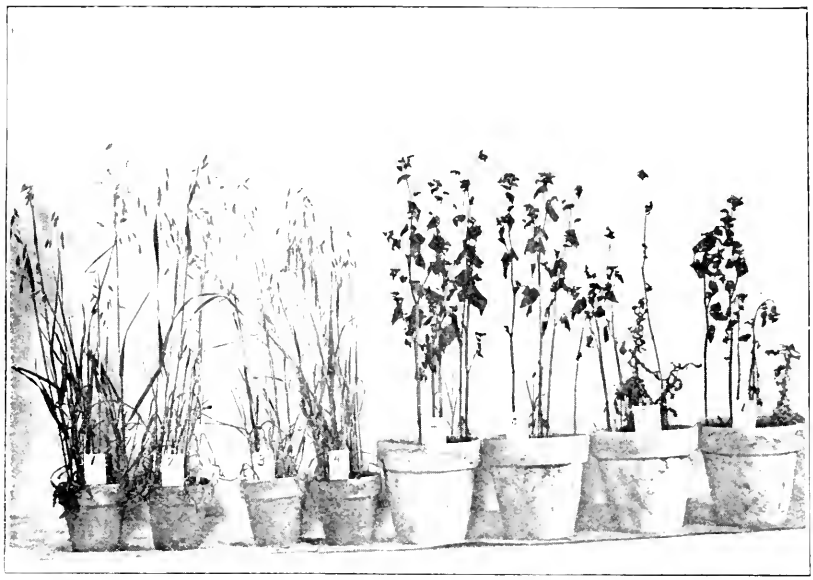
Certain results of experiments with pairs of plants growing in the laboratory in water cultures seemed to point towards a partial explanation of this peculiar condition, and as a result of this hint, a series of experiments was planned to see if any light could be thrown upon this matter by experimenting with pairs of plants in pots. Incidentally it might be mentioned here that the Canada thistles do not reproduce by seed to any very great extent, and not by any means so extensively as is commonly supposed. They reproduce by underground stems which sometimes extend out through a radius of four or five feet in one season. This underground system of the Canada thistle is often very deep and extensive and the suggestion arises as to the effect it might have upon the soil and directly or indirectly on the other plants growing in the same soil.

It is a well known fact among farmers that the thistle patches in the field persist as patches for many years, spreading if neglected, but holding their own generally when once they gained a deep foothold. Such patches then might be supposed to exert some kind of influence upon the soil from continued occupation of the ground by thistles.

The experiments here described were planned to show whether the underground system of the thistle did affect the crop growing in its neighborhood.

Flower pots, some 4-inch and some 6-inch were sunken into the ground and then fitted with a well mixed rather poor sandy loam soil. It was not deemed necessary at this stage to pay much attention to the chemical condition of the soil, supposing that for practical purposes the main thing was to have the soil all alike and well mixed.

When the soil and pots were all prepared four 4-inch pots and four 6-inch



PHOTOGRAPH 1.—The four pots to the left are sowed to oats, Nos. 1 and 2 contain Canada thistles as well. Nos. 3 and 4 contain oats alone.
The pots to the right contain buckwheat; Nos. 1 and 2 contain thistles also; 3 and 4 are clean.
The pots to the left are 4-inch pots and the other 6-inch.

PHOTOGRAPH 2—Nos. 1 and 2 contain oats, and in each of the two pots is a young elm tree, Nos. 3 and 4 contain oats alone. Six inch pots.

pots were sown with oats alone and a similar number sown with oats accompanied by a vigorous looking underground shoot of Canada thistle. Besides oats the following were used in a similar arrangement: barley, buckwheat, wheat and flax. In connection with these sets another pair was arranged. Young elm trees were planted one each to a 6-inch pot and oats grown alongside.

A number of accurate measurements and observations were made from time to time and records made. A summary of these present results partly seen in the accompanying photographs, which represent not the extreme but the average results as well as could be estimated. In photograph 1 to the left are the pots of oats, 1 and 2 having thistles planted with the oats, while 3 and 4 have oats alone. In the same photograph to the right, are four 6-inch pots sown to buckwheat, 1 and 2 having thistles planted with the buckwheat while 3 and 4 are clean. With the oats the thistles seem to do no harm and if anything tend to increase the crop. The buckwheat shows the result exactly opposite. Now, these results are not intended to be final by any means. They are only calculated to represent one set of experiments carefully carried out.

In photograph 2 the oats when accompanied by the elm tree (about 10 inches high) indicate a poorer crop than oats alone.

Whether these results would appear under other conditions and in other kinds of soil is something we cannot predict. Experimental answers are the only answer to the question. It is not as yet an easy matter to account for this; yet it may be fair to suppose it arises out of one of two causes, (1) Injurious excreta which might injure directly the roots of the neighboring plant or might tie up soluble nutritive matter of the soil. (2) This is the exact counterpart of the preceding, where we might imagine excreta to stimulate favorably the roots of a neighboring plant, or to release nutritive material otherwise unavailable.

Incidentally it might be worth while to give the results of one or two observations of the seedlings earlier in the season.

In 22 days after planting, it seemed quite clear that the thistles stimulated the oats, barley and wheat distinctly. This was more particularly noticeable in the smaller pots. The results appeared much more pronounced than at the time when the photographs were taken (58 days after planting).

Not far from where these pots were placed in the garden, there grew a young poplar tree about two and one-half inches in diameter. Corn was planted in the garden about the tree. The crop of corn within a radius of six or eight feet of the poplar tree was so distinctly poor as compared with the corn in other parts of the garden, that I concluded I had a rival experiment but not of my own planning. That such a result was not a matter of shade was proved by the fact that in another portion of the garden similarly situated with reference to the corn was a black locust tree nearly the same size. The crop of corn in the neighborhood of the locust tree was about the same as the average of the garden crop. Another observation showed that it was not a matter of shade. In a field of corn in this neighborhood there grew an oak tree which was cut down and removed just about the time the corn was planted. Now the crop of corn was so poor around the stump of this tree that every passer by could not fail to notice it. The matter of shade was of course entirely eliminated. It must have been a soil question purely. Such field observations might be called supplementary and in a sense they are more important and more conclusive than those conducted in pots.

East Lansing, April 15, 1909.

SOME RECENT OR ADVANCED METHODS IN THE ANALYSIS OF MILK.

W. E. Robison.

I think ten minutes will amply suffice in which to tell you what we are doing in regard to "Recent or Advanced Methods" in the analysis of milk at the Dairy and Food Department. First of all, our work is quite necessarily limited to the study of adulteration of food and drink products. Therefore, the methods which are under study in regard to milk are methods chiefly for the determination of water, that being the chief adulterant of milk, as well as of sausage and a great many other food products, and some products which are not foods.

In our study of milk by the common methods of analysis, while we have been able to state with comparative certainty when a milk has been grossly watered, we have not been able to state with any degree of accuracy to what extent it has been adulterated, because we do not know the composition of the original milk, and to assume that a given sample of milk is adulterated, either skimmed or watered, because it falls short of the arbitrary requirements of the statute, is to work injustice in many cases. For instance, the milk of Coloma Canary of the college herd, referred to in table below, is below the standard required by the statute, yet is not adulterated, while on the contrary, the milk of Daisy or Bonnie May might be quite badly adulterated and still be within the statute.

We may be able to say from the more common methods of analysis however, that a sample contains at least 10% or 20% added water, as the case may be. But is it not possible that something more definite can be ascertained? In order to satisfy ourselves on this question, we have been led to the use of the Zeiss Immersion Refractometer, and Beckman's apparatus for the determination of the freezing point depression of liquids. And while the refractometer proves of great value when used as cumulative or corroborative evidence, it does not enable us to answer the question "how much?" Both methods are being used to some extent in some of the foremost laboratories in this country and abroad. In the comparatively small amount of work I have done with them together, I have found that the freezing method gives closer results than the refractometer, and I wish to call your attention to some of the data in hand as given in the table below.

Now for the purpose of ascertaining the effect of added water, I have taken a portion of the milk of the Jersey and diluted it very carefully with distilled water, making additions of 50%, 25%, 10%, 5%, and $2\frac{1}{2}$% respectively, and the freezing point depressions are as given in the table. It will be noticed that this checks within exceedingly narrow limits with the theoretical, and using so many different pipettes in the sampling may possibly explain a part of the slight variation. This data gives us a very good view

Name of cow.	Breed.	Specific gravity.	Total solids. %	Fat. %	Solids not fat. %	Ash. %	Refractive No. @ 20°C.	Freezing depression. Of milk.	Freezing depression. Of serum.
*Coloma Canary	Holstein.	1.032	11.96	2.7	9.26	.712	41.3	.56	†.795
Bon Heur Lassie II.	Holstein.		11.80	3.3	8.50	.643	39.1	.56	.795
Colantha Queen II	Holstein.		12.20	3.3	8.90	.642	39.9	.56	.795
College Bell Yekema Sarcastic	Holstein.		12.17½	3.1	9.075	.765	40.6	.56	.795
Bonnie May	Guernsey			6.4			41	.56	
Daisy	Jersey.	1.036	13.45	4.6	8.85	.775	41.8	.56	

*Two samples give same freezing point.
†The serum is the same liquid as used for refractive index.

Amount of added water.	Freezing depression.
50 per cent.	.59
25 per cent.	.42
10 per cent	.51
5 per cent	.53
2½ per cent	.54+

of the comparative value of different determinations on a few milks. In the Holsteins, the fat, solids, ash and refractive index vary considerably, while the freezing point depression remains constant. And although the Jersey and Guernsey are much higher in solids, fat, ash, etc., the freezing point depression is the same.

Lansing, Mich., April 15, 1909.

OSMOTIC THEORIES (WITH SPECIAL REFERENCE TO VAN'T HOFF'S LAW).

[Abstract.]

J. B. Dandeno.

There is no subject in plant physiology of more fundamental importance than osmosis. It is not confined to plants alone, but is universal as far as physiological operations are concerned, whether of plant or animal. Indeed, wherever a living cell is active, either in the matter of intake, or outflow, osmosis is a prominent feature of the operation. Yet it is not in itself a biological operation, though it is almost universally found in connection with such activities. It is purely physical, or physico-chemical in its nature, and it is from these sources that we may expect a reply to the question as to the true nature of the phenomena.

A considerable amount of work in physiology has been done, which bears more or less closely upon osmosis, yet very little experimental facts have been produced either in biology or physical chemistry which can be said to throw much light upon the fundamental principles. The most important investigators were Pfeffer, de Vries and Morse with associates. Pfeffer's researches were made with a view to determine the magnitude of osmotic pressure, and he developed an apparatus—the Pfeffer cell—which has ever since borne his name. A description of this may be found in Goodale's Plant Physiology, p. 227, and also in other works. This apparatus can be used as the basis of quantitative experiments with almost any kind of solutions.

The researches of de Vries were physiological, mainly. He aimed to determine the relative osmotic pressure in the cells of different plants, and, so far as the relative pressure was concerned, his conclusions might be considered quantitative. The results of Pfeffer and de Vries were taken up later by van't Hoff, and from these data he (van't Hoff) formulated a law or theory, since known as van't Hoff's Law.

This law has a remarkably wide acceptance, particularly among physicists, and is given in all the more prominent texts as the only explanation of osmotic pressure, and of osmosis in general. The law, put in simple form, is this: "Osmotic pressure is gas pressure, the result of the impact of molecules of solute upon the bounding surface of solution;" and "the osmotic pressure of a solute is the same as it would be if in the form of a gas and occupying the same volume." The idea involved in this law has very frequently been used in an attempt to explain osmotic phenomena, but the difficulty of the matter is that there are so many features it does not explain, and there are several experimental results which are entirely opposed to it.

The most important argument brought against the validity of van't Hoff's law is the experimental quantitative results of Morse, which go to show that the pressure in a sugar solution, for a grammolecular weight per liter is more (nearly as 3:2) than what it would be theoretically according to van't Hoff's law. There has been quite a number of experimental facts deduced by the writer and others, which go to show that van't Hoff's theory is no

longer tenable, either as an explanation of osmotic pressure, or of osmosis in general. It is not only inadequate, but is opposed to experimental facts of a purely physical nature.

Physiological experiments on plasmolysis and operations related to it, go to show that we must look to other sources for explanatory ideas, than to the famous van't Hoff's law. The activities of an osmotic character in the plant cell cannot be explained on that ground, consequently we must look to other processes.

There have been several other theories offered to explain osmotic action, but none of them has received the general prominence or acceptance accorded to van't Hoff's law. The more important of these theories may be designated as follows: Surface tension, capillarity, molecular attraction.

Without going into detail explanatory of these, it may be said that there is less or more to be said in favor of each. Of the last we have this to say that if applied generally enough it proves satisfactory. But in writing this paper, we have in mind an explanation defining and explaining this attraction to suit the needs of the case.

The explanation here offered postulates two things: (1) That molecules of substances have by nature an attraction for one another and that the amount of such attraction will depend upon the character of the substance. (2) That a membrane may be obtained which is more porous to the molecules of one substance than to those of another. By this is meant that a membrane (e. g. copper ferro-cyanide) may offer more resistance to the passage of a molecule of one body than to that of another whether it be due to the *size* of the molecule, to the relative *shape* of the molecule and pore, or to an attraction, positive or negative, between the substance of the membrane itself and that of the molecule passing. These two postulates are so self evident that no explanation is necessary. When liquids are arranged with a membrane between, as in any ordinary osmometer, a molecular attraction comes into play, but it operates only at very minute distances, hence to develop high osmotic pressures it is necessary to stir the liquids. The amount of pressure which a given substance may exert will depend on the specific character of the molecule, as well as upon the number of molecules present.

As this is a mere abstract, details of explanation cannot be gone into as fully as might be wished. It is, however, intended that the attraction theory above referred to affords a basis for a reasonable explanation for osmotic phenomena of every character. It is, as already indicated, contended also that van't Hoff's law is not a valid hypothesis when relating to osmotic pressure.

East Lansing, April 1, 1909.

INVESTIGATION ON THE TOXIC ACTION OF BORDEAUX MIXTURE.

(Continued.)

J. B. Dandeno.

This work is a continuation of that given before this section of the Michigan Academy of Science at the meeting of April, 1908, under the title of "The Toxic Action of Bordeaux Mixture and of Certain Solutions on the Spores of Fungi," and published in the tenth report, 1908, p. 57. In the paper whose title has just been mentioned, it is stated that the Bordeaux liquor problem needed further investigation in view of certain facts recorded there. The most striking features of the mixtures which seemed to require further research were. (1) That the supernatant liquid was toxic to a very considerable extent, when, according to the potass-ferro-cyanide test, it contained no copper whatever; (2) That, in certain instances, the Bordeaux mixture showed more toxicity in grades of solution more dilute (see tables on page 60 of the report quoted above). One expects the toxicity to increase as the strength increases. These two ideas gave rise to the investigation given here below.

The Bordeaux mixture was prepared from the ordinary formula: 5 lbs. copper sulphate; 4 lbs. lime, and 50 gallons water. This was the stock solution, and the various dilutions were made from this as follows: One-half, one-fourth, one-eighth, etc. To test the toxic activity of the liquids, seedlings of pea, corn, and lupine were employed. For each test a sufficient quantity (25 cc) for each seedling was used. It has already been demonstrated by the writer* that a quantity of liquid greater than 25 cc has no further effect appreciable, consequently, for these seedlings, 25 cc represents a quantity giving the maximum effect so far as quantity alone is concerned. The radicle of each seedling was immersed for a distance of 20 mm or more and allowed to remain immersed for at least 24 hours. The test of death to the radicle was a growth test. If the radicle grew in the reagent this was held as conclusive proof that the liquid was not sufficiently toxic to kill it. If the radicle did not grow, then it was concluded that death resulted.

The supernatant liquor of the Bordeaux is of course a strong solution of some compound of lime but properly contains no copper. This, when titrated with acid, showed a strength of lime of, $^{N}/_{24.8}$ or very approximately one-twenty-fifth normal. It is interesting to note in connection with this strength, that a saturated solution of lime (quick lime in water) at laboratory temperature proved to be, on titration, $^{N}/_{23}$, a solution only very slightly stronger in lime than the supernatant Bordeaux liquid.

The first set of experiments were made to determine at what strength the supernatant liquor might be and yet just permit growth of the radicle. This supernatant liquor was siphoned from the stock Bordeaux after it had been allowed to settle, and then diluted down in fractions, one-half, one-fourth, one-eighth, etc. The result of a number of experiments showed

*American Jour. Sci., June, 1904, p. 446.

that all three seedlings (pea, lupine, corn) tolerated a solution strength of $^1/_{32}$. None grew in $^1/_{16}$, the next grade stronger.

A saturated solution of lime employed in a similar manner gave the following result. All three seedlings grew in a solution strength of one-eighth, but none grew at one-fourth, showing that when the supernatant Bordeaux is compared with saturated lime water, it is found that the Bordeaux is four times as toxic.

Bordeaux mixture whole, i. e., the precipitate and supernatant liquor together, presented another interesting problem. When the Bordeaux is fresh, i. e., when used within a week or ten days after its preparation, the seedlings withstand a strength of about $^1/_{128}$, both corn and pea, but not the lupine, growing in this. When the Bordeaux mixture is allowed to stand a month or so, similar seedlings withstand then a strength of about $^1/_{2048}$. This is about 16 times as dilute as that in which the test was made with freshly prepared Bordeaux.

Another difference which developed was this: If Bordeaux be prepared, well shaken and divided into two portions, one set aside as it is and the other diluted to about $^1/_{256}$, and then set aside, in four or five weeks after this, tests made with both show that seedlings withstand (of that not diluted till used) a strength about four times as great as that diluted when prepared. These phenomena were shown particularly with the lupine. These radicles always turned yellow showing by this some reaction with the liquid which was not apparent with either of the other two seedlings. In fact the lupine became yellowish in solutions as dilute as $^1/_{8192}$.

As a matter of fact Bordeaux mixture should not be any more toxic than the supernatant liquid, because the copper, which is the toxic element, is in the form of an insoluble precipitate, and consequently as such could not react upon the radicle of the seedling. The experiments above mentioned show that the mixture is at least four times as toxic as the liquid alone. This excessive toxicity is clearly due to an interaction between the radicle and the precipitate, indicating that roots of plants can react chemically upon insoluble compounds in the solution. As has already been pointed out, this was especially noticeable with the lupine.

A number of vials of the various grades of the diluted Bordeaux was set aside for several months, some of them for more than a year, and then it was seen that the copper underwent during this time some decomposition, because a dark brown precipitate appeared in connection with the blue, in from one to six months; and this appears more particularly in certain grades of dilution commencing at about one-fourth. The whole Bordeaux, full strength, underwent the least apparent decomposition as indicated by the absence of any formation of free copper, or of copper oxide.

One very peculiar result developed especially with the corn seedlings. Corn repeatedly grew in a strength of supernatant liquid of one-fourth while it would not grow in one-eighth. This phenomenon was observed by the writer in experiments reported in the tenth report of the Michigan Academy of Science, 1907, p. 60, concerning fungus spores. Some of the experiments there described indicate that spores would germinate at a certain dilution, and fail to germinate in the next one or two grades more dilute. No explanation was offered at the time, but now it seems reasonably clear that the comparatively rapid decomposition which goes on in more dilute solutions is accountable for this rather striking phenomenon. For example, corn grew in a dilution of one-fourth and failed to grow in one-eighth. This can be explained by assuming that the more rapid decomposition in the

more dilute solution compensated for the more material in the stronger solution.

A chemical examination of the Bordeaux mixture used for the above experiments revealed the fact that the copper sulphate must have contained iron, because this was present in the supernatant liquid, and accounts for its toxicity over that produced by the lime. This is the only explanation for the excessive toxicity of fresh supernatant Bordeaux which is made from commercial copper sulphate and which practically always contains iron. In the more dilute grades of Bordeaux, which has been allowed to stand for a considerable length of time, copper appears in the supernatant liquid in solution as the result of slow decomposition.

The more important commercial results to be deduced from these experiments are that Bordeaux mixture becomes more toxic as it becomes older and consequently may do damage that it would not do if used fresh. Bordeaux reacts readily upon living parts of plants, the precipitate entering into the reaction as shown by the lupine radicles. The amount of such reaction will depend upon the character of the plant substance with which the precipitate comes into contact.

East Lansing, April 1, 1909.

THE RAPID EXTENSION OF WEEDS IN MICHIGAN.

W. J. Beal.

In volume five of the Michigan Academy of Science, may be found an approximately correct list of weeds indigenous to Michigan. This list consists of about thirty-five species only. The same report contains a list of seventy-eight species of weeds introduced from Europe and Asia.

For use in the laboratory, I have a list of two hundred and six species of weeds to be found thriving in this state, and I feel sure that if this state was thoroughly searched, fifty or more additional ones would be found, and where the limit will eventually be, I dare not predict.

HOW ARE WEEDS INTRODUCED AND HOW ARE THEY SPREAD?

1. By live stock, carried in the hair or fleece or carried by the feet; in some instances passing alive with the excrement.
2. By unground feed stuff purchased.
3. By adhering to the insides of sacks where they were placed with grain.
4. In barnyard manure drawn from town.
5. In the packing of trees, crockery, baled hay and straw.
6. By wagons, sleighs, threshing machines.
7. Sometimes by plows, cultivators and harrows.
8. By railway trains passing near a farm.
9. By ballast of boats at wharves.
10. By wool-waste at factories.
11. By birds, squirrels, and mice.
12. By water of brooks, rivers, by washing and by irrigating ditches.
13. By the wind aided by little wings and by drifting on the snow.
14. By dropping seed to the ground from extending branches and repeating the process.
15. By creeping rootstocks, as June grass, quack grass and toad-flax.
16. By piercing potatoes, carrots, etc. Quack grass, June grass, Bermuda grass are sometimes carried to other fields or farms where the tubers and roots are planted.
17. As every kind of weed goes onto a farm to stay there, it follows that as a country becomes older the greater the number of kinds of weeds. As a rule, each farm is annually getting more sorts of weeds, and as each farmer is cultivating weeds, they are more freely distributed in every field and along every roadside, and by exchanging seeds, they are carried to neighboring farms.

A great many farmers buy and sow whatever the merchant offers them under the name mentioned. For example, I have a sample of something called clover seed, sold by a dealer in this state. It contains about 40% of narrow-leaved plantain, which I consider one of the worst of clover weeds. A large majority of weeds hail from older countries, more especially from Europe.

There are a few weeds, like Canada thistle and quack grass, that may infest any crop of farm or garden, but in most cases, whether to call a weed

very bad depends on the nature of the crop grown, the size of the seed, and their time of ripening.

Some weeds have a very wide distribution, thriving all around the world in temperate climates, while others are more limited in range; some thrive only in dry, thin soil and others in wet soil. To some extent the presence of a few weed seeds is almost as objectionable when once on the farm, as though there were more, because these few thrive and seed freely.

In many respects the list of weeds for New Jersey is different from the list in Michigan, while half the weeds of Nevada or Oregon are not known in our state.

Chess, cockle, red root, rye are liable to be troublesome in fields of winter wheat, because the seeds are more or less difficult to separate from this grain and for the reason that they require a portion of two years to come to maturity. When the thrifty farmer screens out the smaller grains of wheat to get the large grains for seed, by the same process he has screened out seeds of cockle, and unintentionally bred up a race that bears larger seeds.

Meadows and pastures, especially where the land is not fertile, abound in weeds that require two or more years to produce seeds, such as narrow-leaved dock, bitter dock, bull thistle, carrot, teasel, two kinds of mullein, night-flowering catchfly, evening primrose, several kinds of fleabane, ox-eye daisy, orange hawkweed, two or three kinds of plantain, Canada thistle, hound's tongue, stick seed, sow thistle, horse nettle, buttercups, toad flax, silvery cinquefoil, and many more, not excluding some annuals, like crab grass, tickle grass, the pigeon grasses. As crops of corn, potatoes, beans, turnips, beets, squashes are ready to harvest at the close of one growing season they are molested more or less by pigeon grasses, several pigweeds, purslane, crab grass, barnyard grass, tickle grass and a number of others.

WHAT ENABLES A PLANT TO BECOME A WEED?

1. Sometimes by producing an enormous number of seeds. A large plant of purslane produces 1,250,000 seeds; a patch of daisy fleabane, 3,000 seeds to a square inch.

2. In other cases by the great vitality of their seeds. Shepherd's Purse, purslane, mustard, mayweed, pepper grass, evening primrose, smart weed, narrow-leaved dock, chickweed, pigweeds, pigeon grass, survive for 25 years or more, as I have proved by testing them.

3. Some plants are very succulent, and ripen seeds even when pulled. (Purslane).

4. Often by ripening and scattering seeds before the cultivated crop is mature. (Red root, fleabue).

5. Sometimes by ripening seeds at the time of harvesting a crop, when all are harvested together. (Chess, cockle).

6. Some seeds are difficult to separate from seeds of the crop cultivated. (Sorrel, mustard, narrow-leaved plantain and the two pigeon grasses).

7. Some weeds are very small and escape notice. (Mullein, fleabane).

8. Some plants go to seed long before suspected, as no showy flowers announce the time of bloom. (Pigweeds).

9. In a few cases the plants break loose from the soil when mature and become tumble weeds. (Some pigweeds, Russian thistle, winged pigweed).

10. Some remain with the dead plant long into winter, and when torn off by the wind or by birds, drift for long distances on the snow, often from one farm to another. (Pigweeds).

11. Some seeds and seed-like fruits are furnished each with a balloon, or a sail, or with grappling hooks. (Dandelion, sticktights, burdock).

12. Two seeds in the fruit of cockle bur are so placed that one grows the first year, and the other remains dormant till the second year.

13. Some have creeping rootstocks or tubers. (Quack grass, nut-grass).

14. Some weeds defend themselves with forks and bayonets. (Thistles).

15. Stout rooted plants are skipped by the cultivator. (Dock).

16. Most of them are disagreeable in taste or odor, so that domestic animals leave them to occupy the ground and multiply. (Jamestown weed, stink grass, milkweed).

I have recently examined 122 samples of clover seeds, which contained 51 kinds of weed seeds; 9 samples of this number contained no weed seeds.

Seventy samples of clover seed contained seeds of *Chaetochloa viridis* (green foxtail).

Sixty samples contained *Plantago lanceolata* (buckhorn).

Fifty-eight samples contained *Plantago Rugelii* (Rugel's plantain).

Fifty samples contained *Rumex crispus* (narrow-leaved dock).

Forty-six samples contained *Rumex acetosella* (sheep sorrel).

Thirty-six samples contained *Polygonum Persicaria* (lady's thumb).

Thirty samples contained *Chenopodium album* (lamb's quarters).

Twenty-three samples contained *Plantago major* (one of the broad-leaved plantains).

Twenty-three samples contained *Panicum Crus-galli* (barnyard grass).

Twenty-one samples contained *Ambrosia artemisiaefolia* (common ragweed).

Seventeen samples contained *Panicum capillare* (hair grass).

Sixteen samples contained *Panicum sanguinale* (crab grass).

Fifteen samples contained *Potentilla Monspeliensis.*

Fourteen samples contained *Amaranthus retroflexus* (our most common rough pigweed).

Thirteen samples contained *Lepidium Virginicum* (one of the pepper grasses).

Nine samples contained *Chaetochloa glauca* (yellow foxtail).

Nine samples contained *Alsine media* (our most common chickweed).

Eight samples contained *Nepeta Cataria* (catmint).

Seven samples contained *Lepidium apetalum* (a small pepper grass).

Six samples contained *Prunella vulgaris* (self heal).

Five samples contained *Cerastium vulgatum* (mouse-ear chickweed).

Four samples contained *Bromus secalinus* (common chess).

Three samples contained *Rumex obtusifolius* (broad-leaved dock).

Three samples contained *Anthemis Cotula* (Mayweed).

Three samples contained *Onagra biennis* (evening primrose).

Three samples contained *Daucus carrota* (wild carrot).

Two samples contained *Panicum lineare* (narrow-leaved panicum).

Two samples contained *Lithospermum arvense* (red root).

Two samples contained *Lolium perenne* (perennial rye grass).

Two samples contained purslane.

Two samples contained *Cichorium Intybus* (chickory).

Two samples contained *Brassica nigra* (black mustard).

Two samples contained *Carduus arvensis* (Canada thistle).

Two samples contained *Cuscuta arvensis* (dodder).

Two samples contained *Verbena urticifolia* (nettled-leaved verbena).

One sample contained *Medicago lupulina* (black medick).

One sample contained *Ranunculus bulbosa* (bulbous crowfoot).

One sample contained *Ranunculus repens* (creeping crowfoot).

One sample contained *Sinapis arvensis* (white mustard).
One sample contained *Verbena hastata* (blue vervain).
One sample contained *Chaetochloa Italica* (Hungarian grass).
One sample contained *Carduus lanceolata* (bull thistle).
One sample contained *Arenaria serpyllifolia* (a chickweed).
One sample contained *Amaranthus graecizans* (a tumble weed).
One sample contained *Solanum rostratum* (beaked nightshade).
One sample contained *Lepidium campestre* (a common peppergrass).
One sample contained *Silene vulgaris* (bladder campion).
East Lansing, April 1, 1909.

THE EFFECT OF LONGITUDINAL COMPRESSION UPON THE PRODUCTION OF MECHANICAL TISSUE IN STEMS.

[Abstract.]

L. H. Pennington.

This work was undertaken to determine whether a pressure exerted in the direction of the long axis of a growing stem may act as a stimulus to cause the plant to produce more or stronger mechanical tissue in the part under compression.

For each experiment a series of plants of the same age and of uniform size were selected. The height and at least two diameters of each plant were measured, one diameter of the part to be compressed and the other of the part a short distance above the compressed portion. At a suitable distance from the ground, loops were tied around each stem, which was protected from injury by pieces of soft cloth. Each plant was then securely fastened in a perpendicular position by stakes to prevent bending or swaying, and weights were suspended from the loops upon half of the plants while the other half were left without weights to serve as controls. At the conclusion of the experiment the plants were measured as at the beginning of the experiment and each stem was tested to determine its resistance to bending and to crushing. From suitably prepared and stained cross sections of the stems, measurements were made to determine the relative amount of mechanical tissue.

Both woody and herbaceous plants were used. The woody plants were sprouts and seedlings of the common locust, *Robinia Pseudo-Acacia*, sprouts of the Aspen, *Populus tremuloides*, and both young and one-year-old sprouts of Sumach, *Rhus glabra*. The herbaceous plants were the common Sunflower, *Helianthus annuus*, the Castor-oil Plant, *Ricinus communis*, and the broad bean, *Vicia faba*. In the case of woody shoots, the experiments were begun in the spring before growth began and continued until autumn, additional weights being added as the stems became able to bear them. In some series of herbaceous stems, very young plants were used, in others older plants were used; some series were kept under compression for a short time, ten to fifteen days, others for longer periods.

In no case however, did the average of a series of experimental plants show a gain in strength or in mechanical tissue over a like series of control plants.

Ann Arbor, April 12, 1909.

THE CULTURE OF FERN PROTHALLIA.

[Abstract.]

ELIZABETH D. WUIST.

1. Excellent cultures of fern prothallia were obtained in porous pots by keeping cultures in bright light and carefully regulating transpiration. The majority of these prothallia were dioecious. Some were monoecious. Prothallia bearing archegonia were made monoecious by placing them in a nutritive solution for a period varying from four to seven days.

2. Spores germinated readily in water in bright light and when transferred to nutritive solutions continued to grow and produced normal functional antheridia and archegonia on dioecious prothallia. Young sporophytes produced, continued to grow in the nutritive solutions.

3. Spores did not germinate as readily in the nutritive solutions as in water upon exposure to bright light.

THE FLORISTIC COMPOSITION OF THE VASCULAR FLORA OF MOUNT KTAADN, MAINE.

LEROY H. HARVEY.

To the plant ecologist alpine floras have an ever inviting interest, nor do they furnish a less attractive problem to the phytogeographer. Surrounded by a lowland sea of unlike species they rise as volcanic islands of isolated forms. This striking discontinuity in distribution and a partial floristic agreement with other isolated peaks and the arctics early invited investigation. The first adequate solution of this interesting problem was advanced in 1856 by Dr. Asa Gray (4, 5, 6) in his glacial relict theory and subsequently elaborated and extended by Hooker (9) and others. In an earlier treatment of the origin of the Ktaadn flora (8) this theory was applied in detail to the genesis of the plant societies of that peak. No detailed analysis of its composition was published at that time, attention being paid only to the general effect of glaciation and recession upon the mass movements of this alpine flora. To take up the latter phase of the problem is the purpose of this paper.

So firmly has the relict theory become established as the solution of this phenomena that we fail in appreciating that any high mountain flora is usually a composite of at least four distinct elements. If we consider only the higher altitudes of the mountain the flora is dominantly composed of arctic-relict species with which occur a possible few preglacial alpine forms and a very limited number of endemic elements. The consideration of the mountain in its entirety, however, demands the recognition of a fourth element in the lowland forms which occupy its ravines and advance up its most mesophytic slopes. Thus we come to designate these four elements

as the (1) arctic-relict, (2) the pre-glacial alpine, (3) the endemic and (4) the subalpine-lowland. This last element should in no wise be designated alpine, extending as it does very generally out into the contiguous lowlands as well as being lowland in point of origin. A fifth element of ruderal species, e. g. *Anaphalis margaritacea, Galeopsis tetrahit, Prunella vulgaris, Plantago major,* etc., which have followed man in his explorations and lumbering operations may be added for sake of complete analysis.

An enumeration shows upon Ktaadn and its lower slopes, mainly above the two thousand foot contour, 221 species and varieties (2, 7). Of these no less than 111 or 46% are distinctly of the fourth element. It is at once apparent that any attempt to distinguish the pre-glacial alpine from the arctic relict species is *a priori* hopeless, and further for our discussion such a distinction would carry but little value. Nevertheless, all evidence seems to point to the conclusion that the former must exist as a small minority in both the alpine and arctic formation. We thus distinguish 118 species as comprising the arctic-alpine element which embraces 54 per cent of the total flora. Of the third category may be noted the single initial endemic *Carex Grahami*, while *Euphrasia Oakesii* is an example of relict endemism, having its only other record station upon Mt. Washington (11).

The glacial theory postulates a pre-glacial, continuous, arctic, circumpolar land zone which under approximately identical climatic conditions and unrestricted latitudinal migration would have possessed an almost uniform flora. With the segregation of Northwestern Europe from Northeastern North America and Northeastern Asia from Northwestern North America as continental evolution progressed certain isolated and distinct floristic regions came into existence as has been so clearly shown by Hooker. It is from these segregated arctic floras which were driven southward in all longitudes during glaciation that we must derive our arctic-relict forms.

In order to point out the exact arctic regional alliances of these 118 species, we may, following Hooker (9) divide the Arctic Realm, which includes a circumpolar belt of 10° to 14° in breadth lying north of the arctic circle, 66½° north latitude, which forms its southern boundary, into five regions: (1) Arctic Europe, extending from Lapland eastward to the Gulf of Obi; (2) Arctic Asia, which begins with the Gulf of Obi and extends to Bering Straits: (3) Arctic Western America embracing the territory from Bering Straits to the Mackenzie Basin; (4) Arctic Eastern America, from the Mackenzie to Baffin's Bay; (5) Arctic Greenland.

To show more clearly the lines of migration of our relict species and their present diverse affinities an American Realm may be defined as extending from the Arctic Realm southward to the United States and composed of two regions: (1) Northwest America, comprising the band of country reaching from Arctic Western America and traversed by the Selkirk's and Canadian Rockies; (2) Northeastern America, the region lying between the southern Canadian boundary and the Arctic Realm. It includes Laborador, New Brunswick and New Foundland.

A third realm, the White Mountain Region, located 161 miles to the southeast, but only 60 miles due south, is introduced to demonstrate the striking differences which may exist between the floras of two mountains within view of each other. This region includes the Presidential Range of which Mt. Washington is the principal peak.

The Maine Region, a fourth division, is considered under two heads: (1) The Main Coast; (2) The Sphagnum Bogs. The state is rich in this latter habitat which owes its origin to glacial ponds and lakes and so bears a pertinent relation to our discussion. The xerophytism of the coast is even surpassed in these drained and undrained glacial ponds; a set of ecological conditions are here operative which must have acted selectively upon forms striving for occupancy when the belts of biota worked northward with glacial recession.

FLORAL ALLIANCES.

The table immediately following will serve to evidence the occurrence of the 118 arctic-alpine forms in these several regions defined.

TABLE I.—REGIONAL DISTRIBUTION OF THE ARCTIC-ALPINE SPECIES OF MOUNT KTAADN.

Number.	Name.	I. Arctic.					II. American.		III.	IV. Maine.	
		Europe.	Asia.	W. America.	E. America.	Greenland.	N. W. America.	N. E. America.	Mt. Washington.	Coast.	Sphagnum Bogs.
1	Lycopodium Selago*	×	×	×	×	×	×	×	×	×	×
2	Lycopodium anotinum	×	×	×	×	×	×	×	×	×	×
3	Lycopodium sitchense			×			×	×	×		×
4	Larix laricina			×	×		×	×	×	×	×
5	Picea mariana							×	×	×	×
6	Abies balsamea							×	×	×	×
7	Juniperus communis var. Montana?	×	×	×	×	×	×	×	×	×	
8	Hierochloe alpina	×		×	×	×	×	×	×		
9	Phleum alpinum	×	×	×	×	×	×	×	×		
10	Agrostis borealis	×				×	×	×	×		
11	Calamagrostis Langsdorfii	×	×	×	×		×	×	×		
12	Calamagrostis canadensis			×	×		×	×	×	×	
13	Trisetum spicatum	×	×	×	×	×	×	×	×	×	
14	Deschampsia flexuosa							×	×		
15	Deschampsia caespitosa	×	×	×	×	×	×	×	×		
16	Deschampsia atropurpurea	×	×	×	×	×	×	×	×		
17	Poa alpina	×		×	×	×	×	×	×		
18	Poa laxa	×	×	×	×	×	×	×	×		
19	Festuca rubra	×	×	×	×	×	×	×	×		
20	Bromus ciliatus	×		×	×	×	×	×	×	×	
21	Agropyron biflorum	×		×	×	×	×	×	×		
22	Scirpus caespitosus	×		×	×	×	×	×	×	×	×
23	Scirpus hudsonianus	×						×	×	×	×
24	Juncus trifidus	×				×		×	×		
25	Juncus filiformis	×		×	×	×	×	×	×	×	
26	Carex stellulata						×	×	×	×	
27	Carex brunnescens						×	×	×	×	
28	Carex rigida	×	×		×	×	×	×	×		
29	Carex lenticularis							×	×	×	
30	Carex atrata ovata								×		
31	Carex scirpoidea			×	×	×	×	×	×		
32	Carex deflexa						×	×	×	×	
33	Carex novae-angliae				×	×		×	×	×	
34	Carex rariflora	×		×	×	×		×			
35	Carex flava	×						×	×	×	
36	Carex saxatalis	×	×	×	×	×	×	×			
37	Carex saxatalis miliaris							×		×	
38	Carex Grahami										
39	Luzula parviflora	×	×	×		×	×	×	×		
40	Luzula confusa	×	×	×	×	×	×	×	×		
41	Luzula spicata	×		×		×	×	×	×	×	
42	Habenaria dilatata						×	×	×	×	×
43	Habenaria obtusa						×	×	×	×	×
44	Listera cordata	×				×	×	×	×	×	×
45	Salix balsamifera							×	×	×	×
46	Salix Uva-ursi							×	×		
47	Salix herbacea	×	×	×	×	×	×	×	×		
48	Salix rostrata						×	×	×	×	
49	Salix argyrocarpa							×	×		
50	Salix phylicifolia	×	×					×	×		
51	Populus balsamifera			×	×		×	×	×	×	
52	Betula alba	×	×				×	×	×		
53	Betula alba cordifolia		×	×			×	×	×		
54	Betula glandulosa		×	×			×	×	×		
55	Alnus crispa		×	×	×	×	×	×	×	×	

TABLE I.—*Continued.*

Number.	Name.	I. Arctic.					II. American.		III.	IV. Maine.	
		Europe.	Asia.	W. America.	E. America.	Greenland.	N. W. America.	N. E. America.	Mt. Washington.	Coast.	Sphagnum bogs.
56	Alnus mollis							×	×	×	
57	Comandra livida			×	×		×	×	×		×
58	Polygonum viviparum	×	×	×	×	×	×	×	×		
59	Arenaria groenlandica					×		×	×	×	
60	Stellaria borealis						×	×	×		
61	Nymphea microphylla	×			×	×	×	×	×		
62	Coptis trifolia		×				×	×		×	×
63	Ranunculus acris	×	×			×	×	×	×	×	
64	Cardamine bellidifolia laxa	×	×	×	×	×	×	×	×		
65	Drosera rotundifolia	×		×	×		×	×	×	×	
66	Saxifraga stellaris comosa	×	×	×	×	×	×	×			
67	Ribes lacustre				×		×	×	×		
68	Ribes triste	×	×	×	×		×	×	×		
69	Spirea latifolia						×	×	×	×	×
70	Potentilla fruticosa	×	×	×		×	×	×	×	×	
71	Potentilla tridenta					×		×	×	×	
72	Pyrus americana	×				×	×	×	×	×	
73	Rubus triflorus							×	×	×	
74	Empetrum nigrum	×	×	×	×	×	×	×	×	×	
75	Viola palustris	×	×	×	×	×	×	×	×		
76	Viola labradorica	×				×	×	×	×		
77	Epilobium angustifolium	×	×	×	×	×	×	×	×	×	
78	Epilobium anagallidifolium	×	×	×	×		×	×	×		
79	Epilobium Hornemanni	×	×	×	×	×	×	×	×		
80	Cornus canadensis			×	×		×	×	×	×	×
81	Pyrola minor	×		×	×	×	×	×	×		
82	Pyrola secunda	×	×	×	×		×	×	×	×	×
83	Ledum groenlandicum	×	×	×	×	×	×	×	×	×	×
84	Rhododendron canadense							×	×	×	×
85	Rhododendron lapponicum	×		×	×		×	×	×		
86	Loiseleuria procumbens	×		×	×	×	×	×	×		
87	Kalmia angustifolia							×	×	×	×
88	Kalmia polifolia			×	×		×	×	×	×	×
89	Phyllodoce coerulea	×				×	×	×	×		
90	Cassiope hypnoides	×	×			×	×	×	×		
91	Andromeda polifolia	×	×	×	×		×	×	×		×
92	Chamaedaphne calyculata	×	×	×	×		×	×		×	×
93	Gaultheria procumbens						×	×	×	×	×
94	Arctastaphylos alpina	×	×	×	×	×	×	×	×		
95	Chiogenes hispidula						×	×	×	×	×
96	Vaccinium pennsylvanicum angustifolium				×		×	×	×	×	×
97	Vaccinium canadense				×				×	×	×
98	Vaccinium uliginosum	×	×	×	×	×	×	×	×	×	×
99	Vaccinium caespitosum						×	×	×		
100	Vaccinium Vitis-Idaea	×	×	×	×	×	×	×	×	×	×
101	Vaccinium Oxycoccus	×	×	×	×	×	×	×		×	×
102	Diapensia lapponica	×		×	×	×	×	×	×		
103	Trientalis americana						×	×	×	×	×
104	Veronica alpina unalaskensis	×	×			×	×	×	×		
105	Castilleja pallida septentrionalis	×	×	×	×		×	×	×		
106	Euphrasia Oakesii								×		
107	Rhinanthus Crista-galli	×			×	×	×	×	×	×	
108	Galium kamtschaticum						×	×	×		
109	Galium triflorum						×	×	×		
110	Lonicera caerulea villosa	×		×	×		×	×	×	×	

TABLE I.—*Concluded.*

Number.	Name.	I. Arctic.					II. American.		III.	IV. Maine.	
		Europe.	Asia.	W. America.	E. America.	Greenland.	N. W. America.	N. E. America.	Mt. Washington.	Coast.	Sphagnum Bogs.
111	Linnea borealis	×	.....	×	×	.....	×	×	×	×	×
112	Viburnum pauciflorum	.....	.....	×	×	.....	×	×	×	.....	.....
113	Viburnum cassinoides	.....	.....	×	×	.....	×	×	×	×	×
114	Campanula rotundifolia	×	.....	×	×	×	×	×	×	×	.....
115	Solidago macrophylla thyrsoidea	.....	.....	.....	.....	.....	.....	×	×	×	.....
116	Solidago Cutleri	.....	.....	×	×	.....	×	×	×	.....	.....
117	Gnaphalium supinum	×	.....	.....	.....	×	.....	×	×	.....	.....
118	Arnica mollis	×	.....	×	×	×	×	×	×	.....	.....
119	Prenanthes nana	.....	.....	.....	.....	.....	.....	×	×	×	.....
120	Prenanthes Boottii	.....	.....	.....	.....	.....	.....	×	×	.....	.....

SUMMARY.

I. Arctic.					II. American.		III.	IV. Maine.		
Europe.	Asia.	W. America.	E. America.	Greenland.	N. W. America.	N. E. America.	Mt. Washington.	Coast.	Sphagnum Bogs.	Mt. Ktaadn has 118 arctic-alpine forms and two endemic species.
67	42	65	65	60	91	118	114	64	36	Species in common with Ktaadn.
56	35	54	54	51	75	99	95	53	30	Per cent in common with Ktaadn.

*The sequence and nomenclature of Gray's New Manual (10) have been followed. The writer regrets that he has not had access to recent contributions to the flora of the arctic regions; however, such may be expected to furnish further detail in substantiation of the conclusions drawn above.

I.—ARCTIC DISTRIBUTION.

Of these 118 species under consideration 91 or 77% are recorded within the Arctic Realm. The regional distribution of these arctic forms is significant and we may proceed directly to their consideration.

1. *Arctic Europe* possesses 67 (56%) of these 91 forms in common with Ktaadn (Table I) which suggests beyond the fact of the closest arctic regional affinity, that Arctic Europe possesses today the richest arctic flora.

From Table II it is clear that Arctic Europe shows the closest floristic affinity with Greenland (80%) and Eastern America (76%); while with Asia (50%) and Western America (46%) this relationship is much less pronounced. Thus Arctic Europe evidences a much closer floristic alliance with regions to the west than to the east, a relation which apparently weakens in either case directly as the distance.

TABLE II.—DISTRIBUTION OF THE ARCTIC-EUROPEAN SPECIES.

53 or 80 per cent are in common with Arctic Greenland.
51 or 76 per cent are in common with Eastern America.
34 or 50 per cent are in common with Asia.
31 or 46 per cent are in common with Western America.

2. *Arctic Greenland* has 60 species (51%) in common with Ktaadn (Table I) whose affinities are computed in the appended table.

TABLE III.—DISTRIBUTION OF THE ARCTIC GREENLAND SPECIES.

53 or 80 per cent are in common with Arctic Europe.
27 or 45 per cent are in common with Asia.
41 or 70 per cent are in common with Eastern America.
41 or 70 per cent are in common with Western America.

Thus Greenland as might be anticipated from Table II shows its closest floristic identity with Arctic Europe, an identity which further research can reasonably be expected to strengthen. While Eastern and Western America exhibit a percentage agreement, it is misleading as they have only 90 per cent of their forms in common (Table IV) which suggests a mixed origin of the Western American flora, a point to which we shall return. Asia, Greenland and Ktaadn are weak in floristic agreement having but 27 species in common.

3. *Arctic Eastern America* shows 65 species (54%) in common with our alpine flora. These 65 forms have the following arctic relationships.

TABLE IV.—DISTRIBUTION OF THE ARCTIC EASTERN AMERICAN SPECIES.

51 or 76 per cent are in common with Arctic Europe.
41 or 63 per cent are in common with Greenland.
31 or 49 per cent are in common with Asia.
59 or 90 per cent are in common with Western America.

Arctic Eastern America thus has its nearest relation with Arctic Western America though more complete data from Greenland may be expected to much increase the number of forms in common. It would appear from Table I that Arctic America was somewhat uniform in its floristic relation with Ktaadn each region having 54 species (65%) in common with it, but it should be noted that only 90 per cent of their 65 species occur in both regions, i. e., Ktaadn has certain affinity with each which is not common to both Arctic areas. In other words, each of these areas furnishes nine species (10% of their arctic-alpine species) to our alpine flora; a percentage perhaps too small for safe generalization when one considers the surety of incomplete data but nevertheless very suggestive as will be pointed out below. When this area's alliance with Asia is noticed it would appear that the arctic flora of Western America was derived from western migration rather than from an Asiatic center for its European character (76%) is strong while it has only 49 per cent of species in common with Asia.

4. *Arctic Asia* possesses 42 species (35%) of the arctic-alpine flora, which are distributed in the other arctic regions as follows:

TABLE V.—DISTRIBUTION OF THE ARCTIC-ASIA SPECIES.

31 or 74 per cent are in common with Arctic Western America.
31 or 74 per cent are in common with Arctic Eastern America.
27 or 64 per cent are in common with Arctic Greenland.
34 or 80 per cent are in common with Arctic Europe.

5. *Arctic Western America.* This region shows 65 species in common with Ktaadn. Their occurance in the other arctic regions may be had from the following table.

TABLE VI.—DISTRIBUTION OF THE ARCTIC WESTERN AMERICAN SPECIES.

31 or 48 per cent are in common with Arctic Asia.
59 or 90 per cent are in common with Eastern America.
41 or 63 per cent are in common with Greenland.
31 or 48 per cent are in common with Europe.

As might be expected Arctic Eastern and Western America show a striking resemblance, but a difference of 10 per cent or 65 species as noted above, points strongly to the probability that the Mackenzie basin may be looked upon as the division line between two distinct biota within Arctic America, a distinction which becomes more and more marked to the south in Realm II. In this connection it is interesting to note that of the 386 alpine species of Colorado listed by Cockerell (1) only one, *Vaccinium caespitosum* occurs upon Ktaadn a very significant fact strikingly emphasizing the strong western arctic affinity of this flora and the existence of an Eastern and Western Arctic Biota.

II.—AMERICAN REALM.

All but the two endemic species are found within this realm and their regional distribution is recorded in Table I. Of the 91 arctic species 100 per cent are in common with Northeastern America while only 82 species or 90 per cent are found in Northwestern America. However the two regions have 88 common species. Of these 79 are arctic forms, while 9 are peculiar to Ktaadn and the American Realm. It also appears that Northeastern America possesses 27 species (24%) unrecorded from Northwestern America, i. e., the former region furnished 24 per cent of the Ktaadn flora of which 75 per cent are of arctic affinity and 16.5 per cent (18 species) peculiarly American.

1. *Northeastern America.* As is shown in Table I Ktaadn has 99 per cent of its species in common with this region. Their further distribution is recorded below.

TABLE VII.—DISTRIBUTION OF NORTHEASTERN AMERICAN SPECIES.

88 or 75 per cent are in common with Northwestern America.
70 or 59 per cent are in common with Arctic Eastern America.
63 or 53 per cent are in common with Arctic Greenland.
68 or 57 per cent are in common with Arctic Europe.
66 or 56 per cent are in common with Arctic Western America.
47 or 39 per cent are in common with Arctic Asia.

2. *Northwestern America* has 91 species (75%) known to Ktaadn which have the following distribution:

TABLE VIII.—DISTRIBUTION OF NORTHWESTERN AMERICAN SPECIES.

88 or 96 per cent are in common with Northeastern America.
65 or 71 per cent are in common with Arctic Eastern America.
57 or 62 per cent are in common with Arctic Greenland.
60 or 65 per cent are in common with Arctic Europe.
64 or 70 per cent are in common with Arctic Western America.
35 or 38 per cent are in common with Arctic Asia.

III.—MT. WASHINGTON.

Ktaadn and Washington possess 114 species in common. The six species not found on Washington are: *Carex saxatalis*, *Carex rariflora*, *Saxifraga stellaris comosa*, *Cassandra calyculata*, *Carex saxatalis miliaris* and *Carex Grahami*. On the other hand it may be pointed out that Washington possesses 18 alpine species not recorded from Ktaadn (11). While further study of Ktaadn may be expected to reduce this number, yet the fact remains that each of these mountains (only 161 miles apart) has its isolated peculiar elements. In species common to both but unknown elsewhere we have a striking case of relict endemism or perhaps post glacial polygenesis from now extinct ancestry. *Carex Grahami* likewise furnishes an interesting case of initial endemism apparently having here its origin, possibly as a mutant.

IV.—THE MAIN REGION.

Of the 120 alpine forms listed 64 or 53 per cent are common to the coast while 36 species (30%) are found in Sphagnum Bogs (Table I). A more thorough study of the bogs of the northern part of the state would surely increase this latter percentage. Of the 64 coast-alpine forms 39 are to be mentioned as in common with the arctics. Among the 36 bog-alpine species we note 26 as occurring within the arctic realm. On the other hand the bogs and coast of the state show 30 of these species in common of which 22 are arctic forms.

These figures at once make clear the striking intimate relations of these four habitats: mountain, coast, bog and arctic and argue physiological identity which is clearly shown in the ecological similarity of the forms tolerant of these habitats. An identical explanation, the glacial relict theory, may be advanced to account for this bog-coast-alpine-arctic floristic and ecological agreement.

DISCUSSION AND SUMMARY.

Hooker (9) has shown that arctic Europe possesses by far the richest flora, some 80 per cent of the total arctic vascular flora of 797 species; while arctic Asia has the poorest, only producing about 29 per cent of the arctic forms and of these 29 per cent approximately 85 per cent are Arctic European. Of the 67 Ktaadn species in common with arctic Europe only 24 (or 50%) are known in arctic Asia, while of the 42 Ktaadn Asiatic forms 34 or 80 per cent are common with arctic Europe. It is thus apparent that arctic Europe is the main center of glacial distribution and that our Ktaadn flora shows striking arctic European affinity with 56 per cent of the total species or 75 per cent of arctic forms in common, while Asia only shows 35 per cent or 46 per cent of Asiatic-Ktaadn forms.

It also seems apparent that from this center migration possibly followed

two routes which may be designated: The Asia-Alaskan and the Greenland-Labrador. This will appear more striking from the following percentages which indicate the species occurring in common on Ktaadn and in the various regions.

Ktaadn and Asia 35 per cent.
Ktaadn and Arctic Western America 54 per cent.
Ktaadn and Northwestern America 75 per cent.
Ktaadn and Europe 56 per cent.
Ktaadn and Greenland 50 per cent.
Ktaadn and Arctic Eastern America 54 per cent.
Ktaadn and Northeastern America 98 per cent.

Thus we may not only consider Arctic Europe as the center of distribution of the Ktaadn alpine flora but that the glacial migration was dominantly by the Greenland-Laborador route and that arctic western America was mainly supplied from this force. A conclusion further strengthened by the fact that while arctic eastern America and arctic western America have 90 per cent of these forms occurring in both regions only 46 per cent of Western America forms occur in arctic Europe while 76 per cent are known to be in common with arctic eastern America.

Another table will readily show further detail of the migration:

Arctic Western America has 90 per cent in common with Arctic Western America.
Arctic Western America has 90 per cent in common with Northwestern America.
Northwestern America has 54 per cent in common with Ktaadn.
Arctic Eastern America has 100 per cent in common with Northeastern America.
Northeastern America has 100 per cent in common with Ktaadn.

The next step is apparent from the following:

Northwestern America has 88 per cent in common with Northeastern America.
N. W. America and Ktaadn 90 per cent. N. E. America and Ktaadn 100 per cent.

It has been noted above that only 91 or 76 per cent of Ktaadn species are arctic in origin; the remaining 27 or 24 per cent are of subarctic affinity and mainly Northwestern American. Of these 27 species 18 are peculiar to Northeastern America which thus furnishes 16 per cent of the Ktaadn alpine flora. Two species as shown above are endemic. Thus the 120 arctic-alpine species are accounted for as summarized in the table below:

TABLE IX.—SUMMARY OF FLORISTIC AFFINITIES OF THE 120 ARCTIC SPECIES OF KTAADN.

91 species	or 76 per cent	are of Arctic affinity.
18 species	or 16.5 per cent	are of Northeastern American affinity.
6 species	or 5 per cent	are of Northwestern American affinity.
3 species	or 1.5 per cent	are of Northeastern and Northwestern affinity.
2 species	or 1.0 per cent	are endemic.
120 species	or 100 per cent.	

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NOTES ON PLANT PATHOLOGY.

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GANODERMA SESSILE MURRILL A WOUND PARASITE ON MAPLE.

In 1905 the writer reported at a meeting of the Michigan Academy of Science an observation that suggested the possible parasitism of Ganoderma sessile Murrill (7th Report Mich. Academy Science). The fungus and the maple tree there mentioned have been kept under observation until the present time, and the results confirm the view there expressed that the fungus is at least a wound parasite. In the seasons of 1905 and 1906 the fungus fruited anew at the base of the tree, hardly rising above the level of the ground, seen first on June 4th. The growth is at first nearly pure white, turning yellow and finally red in a somewhat irregular way. In 1905 it extended a little more than half way around the trunk, not in an uninterrupted sheet, but in four different patches. In 1908 it ceased to fruit except in one of these patches, and on the side where the sporophores had occurred for the several preceding years (under observation since 1904) the wood of the trunk is completely decayed in to the center of the tree. Between this decayed portion and the spot where the sporophore occurred in 1908 there is a strip of cambium still alive, but where this last sporophore developed is another area of dead cambium.

Since in the last three years the fungus has made hardly any progress around the trunk of the tree, it shows little if any ability to attack the live cambium, but it possesses the ability to attack and completely destroy the exposed wood both sap and heart-wood. Ganoderma sessile is therefore to be placed among the wound parasites, at least for the sugar maple, Acer saccharum Marsh. The primary injury to the tree which enabled the fungus to get its start, was probably the cutting off of roots in building concrete walks near the tree. Every year the difference in size between this tree and the others in the same row is becoming more marked.

POLYSTICTUS HIRSUTUS FR., A WOUND PARASITE ON MOUNTAIN ASH.

For several years two mountain ash trees were observed each of which had one of its main branches partly dead, and in each case the dead parts were partly covered by sporophores of Polystictus hirsutus Fr. In both cases the diseased condition was progressive for several succeeding years, the trees gradually dying off. When one of these trees was dug up it was found to be badly rotted at the heart throughout the trunk. In this rotten heart wood was found the mycelium of the same fungus whose sporophores were found on the outside of the dead branches. On pieces of the rotten heart wood placed in damp chambers sporophores of the fungus developed in about two months.

THE CONIDIAL FORM OF A SCLEROTINIA ON PRUNUS SEROTINA.

On May 30, 1905, the writer observed in the vicinity of Ann Arbor, Mich. a number of wild black cherry trees (*Prunus serotina*) which even at a con-

siderable distance seemed to have lost a large proportion of their leaves. Closer examination showed that many of their leaves had fallen to the ground, and that many of the leaves still on the tree as well as many young shoots were turning brown and dying. On the upper side of these dead and dying leaves was observed a thin coating, ashy grey in color, appearing powdery to the naked eye and with a hand lens. The appearance at once aroused the suspicion of a Sclerotinia. This suspicion was the stronger because the cultivated species of Prunus in this country are often badly attacked by the brown rot fungus, commonly called *Sclerotinia fructigena* (Pers).

Microscopical examination disclosed at once that the fungus was a species of Sclerotinia, but not Scl. fructigena. It differed in two well-marked characters from the corresponding stage of that species. The conidia were considerably smaller, and were separated from each other by disjunctors, a character possessed by Sclerotinia vaccinii Woronin, but not by Sclerotinia fructigena.

Attempts to identify the newly observed form with the conidial stage of some known species were not successful. At the time the conidia were first observed the socalled perfect form or ascus fruits were searched for, but unsuccessfully. It was probably too late in the season, since at an earlier date in that same year (April, 1905), Shimek and Seaver collected apothecia growing from the buried seeds of Prunus serotina in the state of Iowa. Seaver sent specimens of the apothecia to Dr. Rehm who described them as a new species, Sclerotinia Seaveri (Ann. Myc. 3:519; 1905). Since Sclerotinia Seaveri Rehm and the conidial form found by the writer at Ann Arbor both grow on the same host, it is probable that they are different stages in the life history of the same fungus.

Reade (Ann. Myc. 6:112. 1908) has recently reported both the perfect and conidial forms of Sclerotinia Seaveri as having been found at Ithaca, N. Y. He describes the conidial stage (chlamydospores) as a new form, Monilia Seaveri Reade, and as his chlamydospore stage is similar to what the writer found at Ann Arbor and Dead Lake, Mich., 1905, this recently described species is now known to occur in three different states, Iowa, Michigan and New York. It may be a serious parasite since the trees first observed with the disease at Ann Arbor were to a large extent defoliated.

Reade gives the size of his chlamydospores (conidia) as 7-15, mostly 8-10 micromillimeters. As found by the writer they were mostly 7-10.8 x 6-9.6 micromillimeters, with a few large ones 12 x 12. The agreement is so close that there is no doubt that they are the same species.

The ascus fruits were found at Ann Arbor, May, 1909.

SCLEROTINIA FRUCTIGENA IN EUROPE AND AMERICA.

Aderhold has suggested (1905) that in the United States the species of Sclerotinia that commonly attacks the stone-fruits may be Sclerotinia cinerea (Bon.) and not Sclerotinia fructigena (Pers.) as has generally been assumed. He bases his opinion on the color of the conidial tufts as they are said to occur on our stone-fruits, on the size of the conidia, and on the fact that in Europe the Sclerotinia cinerea is the one which commonly occurs on the stone-fruits and Sclerotinia fructigena is generally found on the pome fruits, such as apples, pears and quinces, and lastly on the size of asci and ascospores as found in apothecia which Norton (1902) was the first to discover and describe from material collected in Maryland.

To test the correctness of Aderhold's opinion I have made numerous measurements of the conidia of the species of Sclerotinia found at Ann Arbor, and a few measurements of the asci and ascospores in the apothecia of the same species, partly from material sent to me by Prof. Dandeno of the Michigan Agricultural College, and partly from material collected by myself at Ann Arbor, on both peaches and plums. Many collections of the conidial stage have been made, and this form has been used for class work for several years.

As the result of the observations made on material from Michigan I have reached the following conclusions:

1. Only one species has come under my observation on the cultivated fruits in this region.

2. This species is exceedingly common on the stone fruits, plums, peaches, and cherries, but is much less abundant on the pome fruits. I have found it once causing a blight of young leaves and shoots of the Japan quince. Pyrus japonica. Reade (1908) reports it on pomaceous fruits in New York,

3. The size of the conidia (chlamydospores of some authors) is generally smaller than the size usually given for Sclerotinia fructigena, hence they are more nearly like those of Sclerotinia cinerea.

4. The measurements of asci for Norton's Sclerotinia are far smaller than those found in Michigan.

5. There is some reason to believe that the species found here is the same as the one found by Norton (1905) and named by him *Sclerotinia fructigena*.

Reade (1908) obtained material directly from Norton and gives the size of asci and ascospores nearly the same as those found by myself and also the same as Aderhold described for Sclerotinia fructigena in Europe. In that part of the world however this species is found mostly on pome fruits.

The accompanying table shows the measurements of the asci, ascospores and conidia as they have been reported by various people for the two species, Sclerotinia fructigena and Sclerotinia cinerea.

Author.	Sclerotinia cinerea.			Sclerotinia fructigena.		
	Asci.	Ascospore.	Conidia.	Asci.	Ascospore.	Conidia.
Saccardo (1886)			15—17 x 10—12			25 x 10—12
Norton (1902)				45—60 x 3—4	6—7 x 3—3.5	
Woronin (1900)		In open: 12.1 x 8.8 to 13.2 x 9.9			In open: 20.9 x 12.1 to 24.5 x 13.2	
		In culture: 17.5 x 11.2 to 24.2 x 13.2			In culture: 23.7 x 14.9 to 30.8 x 16.5	
Lindau (1907)			12—13 x 9—10			20—24 x 12—14
Schröter (1908)			15—18 x 10—12			18—24 x 10—13
Aderhold (1905)	89.3—107.6 x 5.9—6.8	6.2—9.3 x 3.1—4.6		120—180 x 9—12	11—12.5 x 5.6—6.8	
Reade (1908)				125—215 x 7—10	10—15 x 5—8	10—28 x 7—17 mostly 17 x 11
Pollock				130—179 x 9.2—11.5	11.4—14.4 x 5—7	
					On plums	14.4—24 x 9.6—14.4
					On agar culture	9.6—14.4 x 7.2—10.8

All measurements in micromillimeters.

Several German authors have advanced the view that Sclerotinia cinerea and Sclerotinia fructigena are really one species and represent what would now be called the fluctuating variations of the species. But Woronin (1900) showed with cultures of the conidial stage only, that while the two species on artificial cultures could vary the size of their conidia far beyond that found ordinarily under natural conditions, so that those of Sclerotinia cinerea became larger than those of Sclerotinia fructigena as usually found in the open, nevertheless there were constant differences recognizable whether they were grown on artificial redia or were inoculated into the same host. Hence he concluded that the two species were well marked. This conclusion has been confirmed more recently by Aderhold (see table above) who found the asci and ascospores of Sclerotinia cinerea considerably smaller that those of Sclerotinia fructigena. Whether both these species occur in this country has not been demonstrated. I have seen no evidence of the two species in Michigan, and Reade reports only one of the two in New York. There are two striking differences between the American and European forms of Sclerotinia fructi-

gena. The American form as commonly found has smaller conidia than the European form, and the habitat is different in the two countries. While in Europe the species is found generally on Pome fruits, in America it is much more frequently found on stone fruits.

I am unable to explain the difference between the measurements of asci as given by Norton (1902) and as found by Reade and myself. It is possible of course that there are two species in this country. But Norton's measurements are different from those of both Sclerotinia fructigena and Sclerotinia cinerea. The question suggests itself, are there two species occurring in this country and neither of them Sclerotinia cinerea? I am inclined to think there is a mistake in Norton's measurements. Perhaps he measured only the spore bearing part of the ascus, and not the long slender basal part. The view that Norton's figures are wrong is apparently taken by Reade to whom Norton sent some material supposedly the same as that from which he described the apothecia. Reade gives the asci as in the table.

The table of measurements given above shows that the size of the conidia has a wide range of fluctuating variability for both species, while the size of the asci and ascospores is far more constant except Norton's measurements. The measurements of the asci and ascospores is therefore a more satisfactory means of distinguishing these two species, and probably others, than the measurements of conidia. It may be noticed that in the measurements given by the writer in the table above, the conidia on agar cultures were smaller than those found on plums in the open. Woronin found that in his artificial cultures he got much larger conidia than in the open. However he used rich organic media while mine contained only mineral salts and agar, and the mycelium on which these conidia developed grew from ascospores, and not from conidia. The results indicate that the size of the conidia has a very direct relation to the medium or habitat.

It is worth noting that the ascospores of Sclerotinia fructigena can develop a mycelium on a medium containing no organic material except agar, if the necessary mineral salts are present. The latter used were monopotassium phosphate, magnesium sulphate, and ammonium nitrate.

Many ascospores germinated on the disc, and a number of them were found with a septum after germination. This septum was located sometimes in the middle of the spore and sometimes near one end. Like the mycelium produced from conidia as found by Woronin, the mycelium from the ascospores also produces flask-shaped conidiophores with microconidia, globular bodies 2.5-3 micromillimeters in diameter. In some cases these flask-shaped conidiophores grow almost directly upon the ascospore or crowded on a very short germ tube. Dense tufts of these conidiophores bearing conidia are also found on the well developed mycelium. The two kinds of conidia were found in the same culture. The germination of the ascospore is therefore just like that of the conidia as Woronin found it. Norton did not find the microconidia in his cultures. In the one questionable case he has nothing like the flask-shaped conidiophores in his drawing.

Saccardo in volume 18 of the Sylloge Fungorum gives a description of Sclerotinia fructicola (Winter)] Rehm, first described by Winter in 1883 under the name of Ciboria fructicola, from rotting peach fruits in North America. Winter's measurements of asci and ascospores are all within the limits of those given by Reade for Sclerotinia fructigena (1908) except that Winter gives the width of the ascospores as 4-4.5 while Reade gives them as 5-8 micromillimeters. This difference is too slight to indicate a different species, especially as only one species is recognized on the peach in the U. S.

hence Winter must have had the species that has since been called Sclerotinia fructigena. If the rule of priority is to apply to the species name first associated with the perfect stage, the correct name of this fungus is Sclerotinia fructicola (Winter) Rehm instead of Sclerotinia fructigena (Pers.) Norton.

A NEW SPECIES OF SCLEROTINIA.

Sclerotinia aestivalis Pollock n. sp. Since the preceding part of this paper went to the printer a new species of Sclerotinia has been collected at Palmyra and Ann Arbor, Mich., first by Dr. L. H. Pennington, June 26, 1909, then by myself and several of my students through July and up to Aug. 9. It occurs on old mummied apples that have lain on the ground over winter. It is apparently not a parasite on either the apple or plum, since ascospores inoculated into ripe and unripe apples both sound and bruised did not develop a Monilia stage nor cause a rapid rot of the apples. Similar negative results were obtained on inoculating the ascospores into plums. After several weeks in the moist chamber a very slow rot on both takes place.

Apothecia from one to fifty on a single mummied apple; stalks short, rarely reaching one 1 cm., not more than .5 mm. thick, dark brown and tapering below, lighter colored above; disc from 1-7 mm. in diameter, light reddish brown, flat when mature, radiating ridges and furrows below, not hairy but appearing almost velvety on outside; asci somewhat clavate or nearly cylindrical, short for the genus 51-85 × 6-8.5 mostly 68-75 micromillimeters long, not turned blue by iodine, several from a common stalk when teased out; ascospores narrowly elliptical, 6.4-11.9 × 2-3.4, average size about 8.5-3 micromillimeters.

This species differs from the other species of the genus occurring on fruits in the time at which the apothecia develop. They are usually produced in April or May while this one occurs in mid summer on account of which the species name *aestivalis* is chosen for it.

The conidial stage was searched for where the ascus fruits were found, but none was found. Attempts were made to get cultures of the ascospores as they were shot into the air, but no conidial stage developed. Whether there is no conidial stage or whether the right conditions for its development have not been offered is not at present ascertained.

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ORIGIN OF OAK BURLS.

In October, 1908, an observation was made near Ann Arbor that seemed to show at least one way in which the socalled oak burls or knots may originate. These knots are common on the white oak, and may be found up to a foot or more in diameter, standing out prominently on the trunk or branch, in a form often approximately hemispherical. The form of knot meant is not the one which shows an open wound or "canker," nor such a knot as sometimes forms around the base of a dead branch or stub, but such as show a generally smooth unbroken surface, produced by an hypertrophy of the cambium, long continued on a limited area on the trunk.

The observation here recorded indicated that the primary cause of such hypertrophy may be an injury produced by birds pecking holes into the tree trunk deep enough to penetrate the cambium. The wound callus formed in a series of such holes, instead of covering the wound smoothly, began to bulge outward on the trunk and a large number of these holes near together had become the starting point for one of the knots or burls. The old bark still covering the newly formed callus showed that each hole pecked by a bird became the center of a disturbance of growth. The proximity of these to each other and their large number formed the basis of a knot which would be of a large size from the beginning, on a tree 16 to 18 inches in diameter.

The question arises whether the birds were not boring for insects, and whether the insects may not have been the cause of the growth disturbance. The regularity in the arrangement of the holes seemed to be against this view. Again, it might be asked does the stimulus of the single mechanical injury produce a disturbance of growth which continues for an indefinite number of years, or does the injury produced by the bird offer an opportunity for the entrance of some plant or animal parasite whose presence acts as a continual stimulus to hypertrophy? The observations do not give an answer to this, but the latter alternative seems the more probable. Bacteria are known to induce the formation of knots by hypertrophy of the cambium in several kinds of trees, but even if that is the case here it is the bird that gives the primary injury.

University of Michigan, April 15, 1909.

UNREPORTED MICHIGAN FUNGI FOR 1908, WITH A MONOGRAPH OF THE RUSSULAS OF THE STATE.*

C. H. KAUFFMAN.

The summer of 1907 was characterized by extreme dryness throughout the state. As a result, the business of the mycological collector and student was almost at a stand-still, and very few additions can be made to our flora. It has been possible, however, to work up in detail some of the material and notes of previous summers, and especially the accumulated information on the genus Russula. This paper, then, is again composed of two sections: First, the meagre list of unreported fungi; second, a critical study of our Russulas. In the list of Ascomycetes are included species of the Geoglossaceae which have been studied by Dr. E. J. Durand from specimens collected in Michigan, and now in other herbaria than ours.

ASCOMYCETES.

Exoascaceae.

Taphria aurea (Pers.) Fr. On poplar aments. Washtenaw Co., May 2, fide L. H. P.**

Geoglossaceae.

Microglossum longisporum Durand. Glen Lake, August, 1902, legit. C. G. Lloyd, fide Durand.

Microglossum rufum (Schw). Underw. (Syn. Mitrula rufa.) Bay View, Emmet Co., 1905, legit. C. H. K., fide Durand.

Mitrula phalloides (Bull.) Chev. Legit. Harper, fide Durand.

Gloeoglossum difforme (Fr.) Durand. (Syn. Geoglossum difforme Fr.). Glen Lake. Legit, C. G. Lloyd, fide Durand.

Geoglossum nigritum Cke. Glen Lake. Legit. C. G. Lloyd, fide Durand.

Trichoglossum velutipes (Pk.) Durand. (Syn. G. hirsutum var. Americanum Cke.). See 8th Mich. Acad. Rep.

Geoglossum hirsutum (Pers.) Boud. (Geoglossum hirsutum Pers.) Kent Co., legit, Longyear, fide Durand.

Helotiaceae.

Sclerotinia tuberosa (Hedw.) Fuck. Sandy maple woods. Macon, Lenawee Co., April 21, fide L. H. P.

Elaphomycetaceae.

Elaphomyces granulatus Fr. (Syn. E. cervinus (Pers.) Schroet.) Woods, Cascade Glen, Ann Arbor, Washtenaw Co., August 14, fide L. H. P.

Hypocreaceae.

Cordyceps ophioglossoides (Ehrb.) Link. On Elaphomyces granulatus. August 14, fide L. H. P.

BASIDIOMYCETES.

Polyporaceae.

Boletus peckii Frost. Oak and maple woods. Washtenaw Co., August 20, fide L. H. P.

*Contribution No. 113 from the Botanical Department of the University of Michigan.
**L. H. Pennington.

Polyporus galactinus Berk. (Syn. Spongipellis galactinus (Berk.) Murril).

Agaricaceae.

Cantherellus floccosus Schw. Marquette, 1906. Fide C. H. K.

Coprinus laniger Pk. Black ash logs. Washtenaw Co., May, fide L. H. P.

Coprinus sclerotigenus E. and E. On old cowdung. Washtenaw Co., April, fide L. H. P.

Cortinarius coloratus Pk. In ravine of oak and maple. Washtenaw Co., September 18, 1907, fide C. H. K.

Cortinarius calochrous Fr. In maple and oak woods. Washtenaw Co., Sept. 17, 1907, fide C. H. K.

Leptonia euchroa (Pers.) Fr. Bay View, July 27, 1905. Legit. C. H. K., fide Atk.

Pleurotus subpalmatus Fr. On dead maple log. August 16, 1906. Houghton, fide C. H. K.

Russula aurantialutea sp. nov. In hemlock and mixed woods. Houghton. August 6, 1906.

Russula borealis sp. nov. Hemlock and maple woods. Marquette. August 24, 1906.

Russula densifolia Sec. Detroit. Legit. O. E. Fischer; photograph in Hard's "Mushrooms" as R. adusta Fr., fide C. H. K., from information furnished by Dr. Fischer.

Russula flava Romell. (Reported in 8th Rep. Mich. Acad. as R. decolorans var. constans Karst).

Russula sericeonitens sp. nov. Maple and birch ravines. Houghton. August 4, 1909.

Russula sphagnophila sp. nov. On sphagnum, in sphagnum bog. Sept. 6, 1905. Bay View.

Russula tenuiceps sp. nov. In mixed woods. Marquette, August 26, 1906.

Russula variata Banning. (Probably reported as R. furcata in a previous report). Ann Arbor, July 25, 1907.

Russula xerampelina Fr. (Reported under R. olivacea Fr.)

MICHIGAN SPECIES OF RUSSULA.

RUSSULA. PERS.

(From Lat. *russula* reddish).

Veil none; the trama of the pileus *vesiculose;* gills rigid, fragile, without milky juice, acute on edge; spores globose or subglobose, usually echinulose or verrucose, white, cream, ochraceous or yellow.

Terrestrial, fleshy, putrescent fungi, with a rather glabrous stipe and depressed pileus.

The *pileus* may be red, purple, violet, bluish, yellow, green or white. The *stem* is usually white, sometimes red, or it may be tinged ashy in age. The *gills* are all shades between shining white and egg-yellow, and this fact illustrates how illogical is our present system of classification among the *Agaricaceae.* The *flesh* is composed of large bladder like cells arranged in groups, and surrounded by strands of slender hyphae. Such a structure is said to be *vesiculose,** and probably accounts for the more or less brittle consistency of these plants. The *spores* give the characteristic color to the gills, and do not vary markedly in size. The *taste*, like that of the closely related genus Lactarius is often acrid or peppery, but there are about as many mild tasting species. *Milk* is lacking, although the gills sometimes exude water.

The **Characters** by which the species of this genus are distinguished from each other are of various degrees of constancy and often quite unreliable. This is in part due to the fact that the weather, the condition of the soil, the inroads of larvae or old age often change the characters to a considerable extent. The rain may wash off the colors, the hardness of the soil may interfere with their proper development, or they may lose their taste, etc. when too old. The **Colors** especially are very variable in some species, but as pointed out by Peltereau,† and verified by my own observations, there is always a fundamental color from which the others are derived, so that with sufficient field experience one can recognize a species even under its various color disguises. The **Pellicle** on the surface of the cap has been much used to separate species. It varies considerably between dry and viscid in different species, or even in the same species under different conditions of the weather. With the exception of the first group, it is separable in its entirety or at least in small strips from the margin inwards. On this point the *Friesian* descriptions of the subgenera are quite misleading, in fact this character is entirely relative. In some species the pellicle or cuticle (as it is indiscriminately called) is a thin, membranous viscid covering which can be peeled off almost entirely; in others we have often a considerable adherence of this cuticle, while in the first group the upper surface is not much differentiated. The **Striations** on the margin of the pileus are also of uncertain value for the inexperienced, since even the firm species, of those which possess a pellicle, very often show striations in age. In the species with thin pileus, the attachment of the gills show through as raised lines, which are often tubercular because of the presence of interspacial veins,

*Atkinson's Mushrooms page 253, fig. 212. (1900).
†Peltereau Bull. Trimestrial de la Socicieté Mycologique, Vol. 24, P. .

and even in the mature forms of many of the firm species one can find the striations sufficiently often to cause misunderstandings. Some authors consider the **Forking of the gills** an important diagnostic character, as well as the *veining in the interspaces* of the gills. These two characters are intimately related and forking is for the most part merely a pronounced development of veining. In fact such a large number of species have been observed with veined interspaces and slightly forked gills, especially towards the base, that this character loses most of its value. There are only a small number where the forked gills are important, and even here the effort to use this character has led to endless confusion. The **Reticulations** on the surface of the stem have been reported as marked enough to aid in distinguishing a few species, but I have never seen any which were well developed throughout a single species; usually the reticulations are obscure, and in this condition are often present.

It is difficult, in fact, to obtain sufficient describable characters for the separation of the large number of species in this genus. There has been a tendency* to discredit the value of the acrid or peppery **Taste** which is used by some as a useful character; yet this is still to my mind a most useful and constant character. It is doubtless true that some species show a variation in this respect in old and young plants, or in old decaying parts of plants, but for the most part such variation is accidental, and, it is likely, that where there is marked inconsistancy in this respect in one species, two species are really dealt with. Distinction should be made between acrid and peppery, but the data on this point are hard to get, and not everybody can make the distinction easily. The **Odor** also is often strong enough to be used to good advantage for the recognition of some species. The most important, however, of the characters are those afforded by the **gills**. They may be alternately long and short as in the first group, or they may be all of one length with hardly any shorter or secondary ones. Intermediate cases occur in the subgenus RIGIDAE, but even here the short gills are not very numerous. Their distance from each other and their shape and width are also of some value, since the anterior and posterior ends have a characteristic width relative to each other for each species. The **Color** of the ripe **Spores**, also shown by the gills, are believed by most authors to be very constant, and hence a spore-print of mature plants is one of the essential things to be obtained in the study of these plants. Finally, one of the most valuable characters is the relative **Consistency** of different species. The fragile forms are usually easily distinguishable from the firm and compact species, and this seems of sufficient fundamental importance to be used as a natural character for the separation of the subgenera. It is thus seen from the brief review given above that the genus is difficult, and will only yield to patient and persistent effort on the part of the student.

Because of the rather uniform changes which take place in the individuals of each species while being dried, it is often possible to verify one's identification by comparison of DRIED SPECIMENS of the same species as suggested by Denniston.* This method cannot be used to any extent on the dried gills, hence spore-prints are indispensable.

The Russulas do not lend themselves well to **Photographic** reproduction. The color, which is so characteristic, can not be caught, and the short stem and broad cap prevent arrangements to show on the picture what ought to be shown.

*Denniston: Trans. Wis. Acad. Sci. etc., 1905; Barbier: Bull Soc. Mycol. de France 1908. Vol. XXIV, P. 230.

The Russulas are almost all **Edible** after careful cooking, as even the peppery forms then lose their sharp taste. Because of the uncertainty of identifications several species are still on the doubtful list, although McIlvaine claims to have eaten even the *R. emetica* of evil fame. Certain it is that all the mild forms are perfectly safe when fresh, young and clean.

The **Distribution** of the different species depends apparently on two factors; the nature of the substratum—including soil and forest surroundings, and the climate. Many species are limited to the coniferous regions of the northern part of the state, while others are found only in the oak openings of southern Michigan. Some species are apparently symbiotic and form mycorhiza on the roots of forest trees. Some prefer sandy soil in woods, while others are usually found in open places pushing through hard clay soil in roads, etc. We have at present entirely too few data on the life history of individual Russulas to say much about their relationship to their surroundings.

As has often been observed by collectors, * the Russulas are most abundant in middle summer. If the weather be favorable, i. e. if moisture and warmth have been supplied at the proper time and in proper sequence, Russulas appear in Michigan in greatest profusion during July and the first half of August; after that time they are comparatively few and scattered. In the northern peninsula they appear as a rule somewhat later, but this depends again on weather conditions. A cool or dry early summer is likely to delay the first crop, but does not seem to affect the later limit of their appearance. The result is that there is a sudden and luxuriant fruiting of all forms during a shorter period. In order to throw some light on their distribution throughout the season, a table has been prepared from data collected at Ann Arbor, in what may be considered a favorable year for Russulas. Trips were made throughout the whole summer, averaging every other day except during a period of three weeks of dry weather. The region covered was that of Washtenaw county, and the time extended from July 8, to November 1. All the dates on which Russulas were found have been put down, and the species are arranged in the order of their abundance. The crosses show that one or more Russulas of a certain species were collected on a certain day. The x 'mark' means that they were very abundant on the day in question, while the number one placed with the cross indicates that only one specimen was found. Unfortuately there is no record in a great many cases, but where they were found daily several specimens were usually collected.

*Denniston, l. c.

1907.	June 14.	July 8.	July 12.	July 13.	July 14.	July 16.	July 17.	July 19.	July 20.	July 21.	July 22.	July 24.	July 25.	July 26.	July 30.	July 31.	Aug. 2.	Aug. 3.
Washtenaw County.																		
Russula squalida Pk.	....	×	×	×	×x	....	×x	....	×x	....	×x	×	×	×	×	....	....	....
Russula emetica Fr.	....	....	....	×	....	×	×	....	×	....	....	....	×	....	×	....	....	....
Russula integra Fr.	....	×?	×	×	....	....	....	....	×	×	....	....	....	....	....	....	....	....
Russula fragilis Fr.	×	....	....	....	....	....	×	....	....	....	....	....	....	....	×	....	....	....
Russula aurantialutea.	....	×	....	....	....	....	....	....	×	....	....	....	....	....	×	×	×	×
Russula foetens Fr.	....	....	....	....	....	....	×	....	×	×	....	....	×	....	×	....	....	....
Russula nigricans Fr.	....	....	....	....	[1]×	....	×	....	×	×	....	....	....	....	×	....	×	×
Russula veternosa Fr.	....	....	....	....	....	×	×	×	×x	....	....	....	×?	....	×x	....	....	....
Russula virescens Fr.	....	....	....	....	....	×	....	....	×	....	....	....	....	....	....	×	....	×
Russula erustosa Pk.	....	....	....	....	....	....	....	....	×	×	×	×	×	....	×	×	....	....
Russula alutacea Fr.	....	....	....	....	....	....	....	....	×?	....	×	×	....	....	×	....	....	....
Russula { furcata Fr. / variata Pk.	....	....	....	....	....	....	....	....	×	....	....	....	×	....	×	....	....	....
Russula tenuiceps.	....	....	....	....	....	....	....	....	×	....	....	....	....	....	....	....	×	×
Russula uncialis Pk.	....	....	....	....	....	....	....	....	×	....	....	....	....	....	....	×	....	....
Russula chamaeleontina Fr.	....	....	....	....	....	....	....	....	×?	....	....	....	....	....	×?	....	....	....
Russula Mariae Pk.	....	....	....	....	....	....	....	....	×	....	×	....	....	....	....	....	....	....
Russula lutea Fr.	....	....	....	....	....	....	....	....	×	....	....	....	....	....	....	....	....	....
Russula sordida Pk.	....	....	....	....	....	....	....	....	....	×	....	....	....	....	....	....	....	....
Russula sp.	....	....	....	....	....	....	....	....	....	....	×	....	....	....	....	×	×	×
Russula xerampelina Fr.	....	....	....	....	....	....	....	....	....	....	×	....	....	....	....	×	....	....
Russula { delica Fr. / chloroides Bres.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	×	×	....	....
Russula albidula Pk.	....	....	....	....	....	....	....	....	....	....	×	....	....	....	....	....	....	....
Russula pectinatoides Pk.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	×	....	×	....
Russula { nigrescentipes Pk. / depalleus Fr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	×?	....	....	....
Russula cyanoxantha Fr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Russula flava Rom.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Russula fallax Cke.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Russula lepida Fr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Russula puellaris Fr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Russula pulvernlenta Pk.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
Russula sororia Fr.	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

Fries divided the GENUS RUSSULA into five "tribes," a designation which is no longer used as a subdivision of any group but the family, so we must consider them as SUBGENERA. Some have attempted to raise these subgenera to generic rank. As Peck* pointed out in his monograph of the New York species, the subgenera established by Fries are very unsatisfactory. Any rearrangement however of the Friesian subgenera have so far failed of general acceptance. Massee divided the genus into two groups, one with mild taste the other with acrid taste; characters of no significance as showing natural relationship. Schroeter, followed by Hennings in Engler and Prantl's Pflanzen-familien, has referred all white-spored species to *Russula Pers.*, and all the species with some shade of yellow or ochraceous to a new genus, *Russulina.* This character, by itself, does not seem to me to have generic value. Earle,** in his "Genera of North American Gill Fungi.", has raised all of Fries' "Tribes" to generic rank as follows:

COMPACTAE—*Lactarelis Earle.*

FURCATAE—*Dixophyllum Earle.*

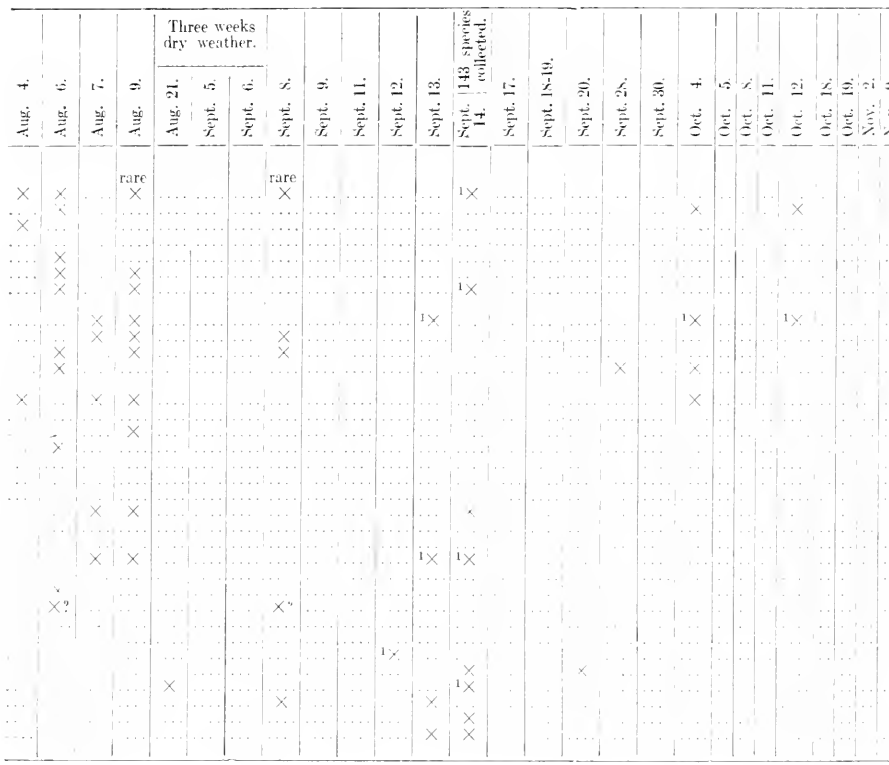
HETEROPHYLLAE—*Omphalomyces Batt.*

RIGIDAE—*Russula Pers.*

FRAGILES—*Russulina Schroet.*

Schroeter's genus has therefore been given different limits by Earle, but the reasons for the change seem to be based on good grounds. Others have

*Peck. N. Y. State Mus. Bull. 116, 1906.
**Earle. Bulletin of the N. Y. Botan. garden. Vol. 5. P 373, 1909.



divided and subdivided the genus in still other ways. For myself, no final statement seems possible at present because of lack of knowledge concerning development in the young stages. All things considered, it seems to me that our American species would better be included in a smaller number of subgenera than Fries used, or in the case of genera, less than those proposed by Earle. In this respect I follow in the main the eminent English Mycologist, M. J. Berkley in his "Outlines of British Fungology,"* who divided the genus into three sections. Using the Friesian nomenclature, the COMPACTAE can be considered as a fairly natural group and can be kept intact. Of the remaining "tribes," the HETEROPHYLLAE and FURCATAE can be dispensed with by referring their species to the two other subgenera—the RIGIDAE and the FRAGILES. The species placed in the FRAGILES fall together quite naturally, and this group can be fairly easily characterized. The RIGIDAE include species normally between the COMPACTAE and FRAGILES in their characters, of which the firm consistency is believed to be more important than the incurved or striate margin and forked lamellae. The character of the young margin, whether incurved or straight, can, however, be used to subdivide the subgenus, and in this paper are provisionally used for this purpose. I believe that future developmental studies will show this a rather important character, concerning which we have no information on a number of species which apparently belong to the RIGIDAE. Three subgenera therefore, or if

*Berkley. 1860.

we follow Earle, three genera, will include our Michigan species and will be characterized below in their proper places.

As a ready means of identification it has seemed best to provide an artificial key for the Michigan species. In this key there are included a number of species which have not yet been reported, but which are known in neighboring states or have always been assumed to be common thruout the country. The difficulties of identification have often been increased by the use of keys to the old subgenera. Since these subgenera are hard to characterize even by experts, such keys have often led to more confusion than clearness, and hence are abandoned here. The key used no doubt has its shortcomings also, but it has been tested in my classes, and seems reasonably serviceable for the identification of the species as understood in this paper.

The study of this genus has been carried on for several years in Michigan under the most favorable conditions. The season of 1907 at Ann Arbor, and the season of 1906 on the southern shore of Lake Superior, yielded Russulas in great profusion. During my visit to Sweden in 1908, I had similar good luck, both in the abundance of species and individuals belonging to this genus, and in the opportunity to associate with Lars Romell* of Stockholm and M. Peltereau of Vendome, France, both of whom have written papers on the Russulas of their respective countries. I am under obligations to C. H. Peck for identification of specimens, and for critical advice, and to a number of friends for favors mycological.

The descriptions of the species given in the following pages, were made from copious notes on fresh, living plants, and are not the result of guesses, in this one respect at least it seems to me information actually important is being offered in this paper. The descriptions, of course, are therefore local and limited, and this fact is thoroughly appreciated; on the other hand systematic mycology would be much more rapidly advanced if we had access to a large number of good local accounts, than by the making of broad generalizations on a few plants from widely separated localities. In all cases, except where noted, the descriptions were obtained from Michigan plants, and are intended primarily to provide the people of the state with a means of identification for their own plants. The critical notes under each species have been appended for a more special class of students, and are intended to help bring order out of the chaos which exists with reference to the identity of American and European species. As can be seen by a study of the notes and references there is considerable disagreement among the European mycologists themselves. It would seem, however, that they have had enough time to straighten out their own tangle, and it is time that we proceed to accomplish something on this side of the water, without waiting for them to agree among themselves.

KEY TO THE SPECIES.

(Numbers refer to text.)

(A) Gills unequal, alternately long and short, flesh thick to the margin of the pileus, which is at first incurved and never has striations. (*Compactae.*)

(a) Flesh white, unchangeable.

(b) Gills subdistant, edge sometimes tinged green. { 1. *R. delica Fr.* / 1. *R. chloroides Brcs.*

(bb) Gills close.

(c) Pileus becoming "sooty-gray." 6. *R. adusta (Pers.) Fr.*

(cc) Pileus whitish, becoming rusty-ochraceous or rusty stained.

(d) Odor strong, alkaline; pileus very large, subviscid; gills with a faint pinkish tinge. 9. *R. magnifica Pk.*

(dd) No odor; pileus dry; gills white, soon "tinged pale cinnamon." 2. *R. brevipes Pk.*

*Dr. M. A. Lindblads Svampbok, bearbetad ax Lars Romell, 1902.

(aa) Flesh becoming black or brown in age or when bruised.
(b) Gills subdistant to distant; flesh becoming reddish, then black where wounded. 3. *R. nigricans Fr.*

(bb) Gills close.
(c) Odor disagreeable on drying; pileus whitish, becoming rusty-ochraceous. 8. *R. compacta Frost.*

(cc) Pileus becoming smoky-brown.
(d) Pileus viscid. 5. *R. subsordida Pk.*
(dd) Pileus dry. 4. *R. sordida Pk.*

(ccc) Pileus or flesh red then black where bruised; gills crowded. 7. *R. densifolia Secr.*

(AA) Gills mostly equal, the shorter ones, if any, scattered promiscuously; margin of pileus not incurved, or if so then striate.
(a) Gills much forked thruout; pileus firm and compact.
(b) Gills crowded; pileus purplish, umber or greenish; flesh slowly acrid or astringent. 20. *R. variata Bann.*

(bb) Gills subdistant; pileus yellowish-green to brownish-green; taste mild. 21. *R. furcata Fr.*

(aa) Gills forked only at the base, or forking not extensive.
(b) Spores white or whitish.
(c) Pileus white.
(d) Taste acrid. 40. *R. albidula Pk.*
(dd) Taste mild.
(e) Pileus with a viscid pellicle, sometimes tinged yellowish. 41. *R. albida Pk.*
(ee) Pileus with a dry pellicle sometimes tinged pink. 41. *R. albella Pk.*

(cc) Pileus some shade of green or dirty white.
(d) Pileus with a continuous separable pellicle; gills subdistant; taste mild. 24. *R. aeruginea Fr.*
(dd) Pileus areolate or cracked so as to form patches; gills rather close.
(e) Pileus dry, with pulverulent or warty patches on disk, dark green when young, scarcely striate on margin. 18. *R. virescens Fr.*
(ee) Pileus viscid, smooth on disk, mouldy-white to pale greenish-white, margin striate. 19. *R. crustosa Pk.*

(ccc) Pileus some shade of red, pink or purple.
(d) Taste mild.
(e) Gills floccose-crenulate on edge; stem tinged red. 43. *R. purpurina Quel. & Schultz.*
(ee) Edge of gills not crenulate.
(f) Pileus firm and hard or compact, pellicle adnate or lacking.
(g) Pileus rather large, bluish-purple, at times rosy to white, on disk 22. *R. cyanoxantha Fr.*
(gg) Pileus medium size, dull lilac. 23. *R. lilacea Quel.*
(ggg) Pileus without blue or purple.
(h) Cuticle thin, not reaching the margin; gills often stained yellowish-brown; stem white. 23. *R. rosea Fr.*
(hh) Surface of pileus minutely rimose-areolate; stem white or rose color; spores straw-yellow. 10. *R. lepida Fr.*
(ff) Pileus thin, fragile or subfragile.
(g) Pileus about an inch across, sometimes larger, clear pink. 44. *R. uncialis Pk.*
(gg) Pileus dark violet-purple to purplish-red, silky-shining; medium size; solitary. 45. *R. sericeonitens sp. nov.*
(ggg) Pileus bright rosy-red with yellowish spots; rather large; in troops. 42. *R. subdepallens Pk.*
(dd) Taste acrid.
(e) Pileus rather small.
(f) Pileus rosy-red on margin, sordid olivaceous-brown on disk; gills subdistant; usually on moss. 36. *R. fallax Cke.*
(ff) Pileus uniform rosy-red; gills close; in moist places. 35. *R. fragilis (Pers.) Fr.*
(ee) Plants medium to large.
(f) Taste tardily acrid. 34. *R. rugulosa Pk.*
(ff) Taste very acrid.
(g) On sphagnum; large; in troops. 33. *R. emetica, var. gregaria.*
(gg) On debris of very rotten logs; scattered. 33. *R. emetica Fr.*

(cccc) Pileus some shade of brown, yellowish, etc.
(d) Odor aromatic, becoming foetid.
(e) Margin of pileus even, then tubercular-striate, grayish-brown; pileus and stem with yellow pulverulent granules. 28. *R. pulverulenta Pk.*
(ee) Pileus markedly striate on margin.
(f) Pileus straw-yellow to dingy, margin at first incurved. 32. *R. foetens Fr.*
(ff) Pileus reddish-yellow; base of stem stained reddish-brown. 31. *R. foetentula Pk.*
(dd) Odor not marked.
(e) Taste mild; pileus and stem yellow, gills white. 17. *R. flavida Frost.*
(ee) Taste mild.
(f) Pileus dingy yellow, straw-yellow, or dirty yellowish-brown.
(g) Pileus covered with granules; no odor. 29. *R. granulata Pk.*
(gg) Pileus without granules; flesh ashy under cuticle; margin strongly striate. 30. *R. pectinatoides Pk.*
(eee) Taste acrid; pileus gray, grayish-brown, olive brown or umber.
(f) Stem becoming cinereous with age. 27. *R. consobrina Fr.*
(ff) Stem not becoming ashy. 26. *R. sororia Fr.*

(bb) Spores and gills becoming some shade of ochre, yellow, or cream-color. (Spore prints necessary.)
(c) Stem whitish, changing to ochraceous-brown where bruised or handled; odor disagreeable in age. Color of pileus purple, red, olivaceous, etc., very variable. 16. *R. squalida Pk.* (Syn. R. atropurpurea Pk.) (See also R. xerampelina Fr.)
(cc) Stem not with this peculiarity.
(d) Pileus some shade of red.
(e) Taste acrid.
(f) Pileus rigid, polished-slippery, mostly dry, pellicle hardly distinguishable; color dark red; very acrid. 9. *R. rubra Fr.*
(ff) Pileus with a distinct and separable pellicle, bright or rosy-red.
(g) Gills cream or straw-color; margin of pileus even; firm. 37. *R. velernosa Fr. etc.*
(gg) Gills ochraceous-yellow; margin striate; fragile gills and pileus. 38. *R. tenuiceps sp. nov.*
(e) Taste mild.
(f) Stem and gills becoming a translucent honey-yellow with age, fragile; small. 47. *R. puellaris Fr.*
(ff) Stem becoming ashy or blackish. 65. *R. obscura Rom.*
(fff) Stem not like the preceding.
(g) Plants large.
(h) Plants usually large, solitary; pileus dingy or dull red or purplish, often faded; young gills ochraceous; firm. 13. *R. alutacea. Fr.*
(hh) Plants medium large, pileus dark violet-purple or red; young gills yellow at maturity, dusted by the "bright ochraceous-buff" spores; firm. 11. *R. ochrophylla Pk.*
(hhh) Plants often in troops; pileus dull and various in color, not rosy-red; young gills white, becoming cream or ochraceous from the spores; context softer than in the preceding; fragile. 46. *R. integra Fr. and forms.*
(gg) Plants small.
(h) Gills and spores truly ochraceous; stem slender; fragile.
(i) Stem rosy-dusted; pileus rose-red.
(k) Pileus plane. 49. *R. roseipes (Sec.) Bres.*
(kk) Pileus umbonate. 48. *R. sphagnophila sp. nov.*
(ii) Stem white; pileus pinkish, red, lilac, etc., fading to yellowish. 50. *R. chamaeleontinus Fr.*
(hh) Gills and spores pale yellowish, cream color, or ochraceous.
(i) Pileus firm, red, with a whitish pruinose bloom; slightly acrid or mild. 14. *R. Mariae Pk.*
(ii) Pileus not with a pruinose bloom.
(k) Under balsam trees; pileus not uniformly red. 51. *R. abietina Pk.*
(kk) On the naked ground, in woods, pileus very small, red. 52. *R. pusilla Pk.*
(dd) Pileus some shade of green or olivaceous, sometimes with purple.
(e) Stem tinged red; pileus firm, varying purple, brownish, etc., gills cream color. 15. *R. xerampelina Fr.*
(ee) Stem white; pileus olivaceous, no purple present. 25. *R. olivascens Fr.*
(ddd) Pileus some shade of yellow, orange, whitish, etc.
(e) Flesh of stem cinereous when old.
(f) Pileus orange-red, large, becoming paler in age. 54. *R. decolorans Fr.*
(ff) Pileus "flavus" (Sacc.), color not changing, hardly viscid. 53. *R. flava Rom.*
(ee) Flesh not becoming cinereous.
(f) Edge of gills vivid lemon-yellow. 56. *R. aurata Fr.*
(ff) Edge of gills concolor.
(g) Taste mild; plant small to medium; gills egg-yellow. 57. *R. lutea Fr.*
(gg) Taste tardily acrid. 39. *R. aurantiolutea sp. nov.*

I. COMPACTAE. (LACTARELIS Earle.)

The compact, thick flesh, the even margin of the pileus which is incurved when young and the sets of shorter gills which alternate regularly with those which run from margin to stem, are the characteristics of this subgenus. They have the appearance of large Lactarii. There is no pellicle.

1. Russula delica Fr.

(The coarse white Russula.)

Illustrations: *R. brevipes Pk.* N. Y. State Mus. Rep. 54. 1900. Pl. 71, Fig. 1-5.

Pileus large, 10-15 cm. broad, fleshy, firm, convex then umbilicato-depressed to infundibuliform, *dull white*, sometimes stained rusty-brown,

unpolished, pubescent or obscurely tomentose, even, dry, margin not striate. Flesh white or whitish, not changing where bruised. Gills white or whitish, *subdistant* or distant, thickish, narrowed behind and ascending, broader in the middle, few forked, short and long alternating, edge often distinctly greenish. Stem *short*, stout, solid, white becoming dingy, 2-5 cm. long, about 2 cm. thick, equal or subequal, glabrous, often with a narrow pale green zone at apex. Spores globose, 9-10 micr. rarely 11 or 12 micr., tuberculate, white in mass. Taste tardily but weakly acrid. Odor none.

Gregarious, covered with leaves or sand. In the maple, birch or coniferous woods of the north; in oak woods of southern Michigan. Often very abundant in sandy soil. It is a coarse plant much like *Lactarius vellereus Fr.* July to October.

The same plant occurs around Stockholm, Sweden, with the edge of the gills and the apex of the stem greenish. I have never seen the gills colored glaucous-green thruout as shown in Bresadola's figures of *R. chloroides Bres.* The slight acrid taste and unpolished pileus and close gills are used by Peck to distinguish *R. brevipes Pk.* It is significant that Fries in his "Monographia" does not describe the pileus as "nitidus" as he does in Hymen. Europ., and Romell refers the Stockholm plants to *R. delica Fr.*, and knows no shining-capped species. Bresadola would doubtless refer our plant to *R. chloroides (Kromb.) Bres.* because of the occasional greenish tints and the large size. At any rate the two descriptions are hard to keep distinct, and I shall refer our plant to *R. delica Fr.* as it occurs abundantly where Fries collected. Massee has retained the name *R. delica* for a Russula with "polished" pileus.

2. Russula brevipes Pk.

(The short stem Russula.)

Illustrations: N. Y. State Mus. Rep., 43. 1890. Pl. 2, Fig. 5-8. N. Y. State Mus. Rep. 54. 1900. Pl. 71, Fig. 1-5.

Not yet distinguished in this state from *R. delica Fr.* The closeness of the gills varies somewhat in *R. delica*, but well developed specimens do not have actually crowded or close gills. The close gills seem to be the only sufficient character by which *R. brevipes* can be separated from *R. delica*, since the descriptions of *R. delica* are probably at fault when "shining" or "polished" is used for the surface of the pileus. The slight touch of acridity also belongs to *R. delica*, as we have seen.

3. Russula nigricans Fr.

(The blackish Russula.)

Illustrations: Hard's Mushrooms. 1908. P. 184, Fig. 146.

Pileus 7-15 cm., rarely more, broad, fleshy, compact, firm, convex then depressed to subinfundibuliform, margin at first incurved then expanded and elevated, and often irregularly wavy, whitish and clouded with umber when young, soon darker, smoky-umber, subviscid, even, glabrous. Flesh white, changing to reddish where bruised, then blackish. Gills white becoming grayish, *thick* and firm, *subdistant to distant*, interspaces sometimes venose, narrowed behind and adnexed, short and long alternating. Stem stout, hard, rather short, 2-6 cm. long, 1-3 cm. thick, even, glabrous, white becoming smoky umber. Spores subglobose, 8-10 micr., white. Taste mild, sometimes slightly and tardily acrid. Odor none.

Gregarious or solitary. Common in conifer and mixed woods of northern Michigan, in oak and maple, etc., of southern Michigan; thruout the state. July to September.

Our Michigan plants quite often show the marked distant gills characteristic of the Swedish plant, altho plants occur which have only subdistant gills. The flesh, gills, etc. of fresh young plants first turn pinkish-red when bruised then black, but the red stain is often absent in old plants as would be expected by the drying up of the scanty red juice which is supposed to cause this phenomenon.

4. Russula sordida Pk.

(The sordid Russula.)

Illustrations: N. Y. State Mus. Bull. 105, 1905. P. 29, Pl. 98, Fig. 1-3.

Pileus 5-12 cm. broad, fleshy, *dry*, convex-depressed, margin incurved or inrolled, glabrous, dingy-white becoming smoky with age. Flesh whitish becoming blackish-brown or bluish-black where bruised. Gills white becoming blackish in age, *close*, alternately long and short, adnate or slightly decurrent, few forked, rather narrow. Stem short, 3-5 cm. long, 1-2 cm. thick, firm, solid, equal, whitish becoming black where handled. Spores globose, 7-8 micr., white in mass. Taste mild or tardily slightly acrid. Odor none.

Solitary. Hemlock woods. July. Infrequent.

The cap, gills, etc. all turn blackish or bluish-black when bruised *without first turning reddish*. The latter peculiarity distinguishes it from both *R. nigricans* and *R. densifolia*. From the former it also differs in the dry pileus and close gills. From *R. adusta* it differs by the rapid change to black on wounding.

5. Russula subsordida Pk.

Illustrations: N. Y. State Mus. Bull. 105. P. 40, Pl. 99, Fig. 1-5.

This species is said by its author to differ from the preceding, in its viscid pileus, dingy gills, and changing to blackish more slowly. Not yet reported.

6. Russula adusta (Pers.) Fr.

(The scorched Russula.)

Illustrations: Hard's Mushrooms. 1908. P. 183, Fig. 145. Atkinson's Mushrooms. 1901. P. 126, Fig. 6.

Pileus 5-8 cm. broad, fleshy, compact, convex then depressed to subinfundibuliform, whitish then brownish or sooty-gray, glabrous, dry, even. Flesh white, *not changing* when bruised. Gills white, becoming sordid, *close*, *thin*, short and long alternating, adnate to subdecurrent, narrow. Stem stout, equal or subequal solid, white then sooty-gray, 3-5 cm. long, about 1.5 cm. thick, glabrous, even. Spores subglobose, slightly echinulate, 6-9 micr., white in mass. Taste *mild*. Odor none.

Solitary. In mixed woods of northern Michigan, probably thruout the state. July-September.

"On drying the plants do not turn black as do *R. nigricans, R. sordida* and *R. subsordida*. The one most closely allied to it is *R. densifolia Secr.*, which has truly crowded gills and, like *R. nigricans*, first turns red when bruised.

7. Russula densifolia Secr.

(The close-gilled Russula.)

Illustrations: Hard's Mushrooms. 1908. P. 197, Fig. 157. (Probably also Fig. 145.)

See remarks on the preceding. It seems to me that this and the *R. adusta* are rather close, but a study of the plant in its natural habitat may show more differentiating characters than the descriptions so far indicate. It is a question whether mere color changes like those of this plant are specifically important.

8. Russula compacta Frost.

(The compact Russula.)

Illustrations: N. Y. State Mus. Bull. 116. Pl. 109, Fig. 1-4.

This is said to differ from *R. sordida* in the presence of a disagreeable odor when drying, the gills turning reddish-brown when wounded and smoky-brown in drying, the gills are sometimes subdistant, and hence it approaches *R. nigricans*. It has not been recognized, and seems very close to some of the preceding.

9. Russula magnifica Pk.

Illustrations: N. Y. State Mus. Bull. 67. 1903. Pl. X. Fig. 1-4.

Not yet reported from the state.

RIGIDAE. (RUSSULA Fr. in part.)

The pileus is compact and firm, provided with a pellicle which is either closely adnate and manifest or develops more slowly than the flesh beneath and so is broken into areolae or vanishes entirely at maturity, mostly separable on the margin, sometimes viscid. Gills are forked or entire, shorter ones occasionally intermingled.

SECTION A.

Margin of pileus obtuse, at first convergent at stem. Gills broader anteriorly.

9. Russula rubra Fr.

(The Red Russula.)

Acrid. The history of this species is very confusing. In Europe, mycologists are not agreed on the plant which belongs here. Romell says that the plant described by Fries under this name is certainly not the plant which is figured in the plates which are deposited in the museum at Stockholm and which Fries approved. Peltereau says that the modern plates and descriptions of *R. rubra* are so confusing and so different from the type that "c'est une vrae tour de Babel." He thinks Quelet's *R. rubra* is like a *R. lepida* with a deep color and acrid taste; that Bresadola's has a white stem and reminds of *R. Clusii Quel.;* that Romell describes a plant which must be *R. lepida* as at present known in France, the Swedes seeming to have lost the traditions of the *R. rubra* of Fries. Peltereau concludes that since there is such confusion the name would better be dropped. Peck gives the following description of a species which he refers to *R. rubra Fr.*, but which I have not yet observed in Michigan.

"Pileus fleshy, *hard*, rigid, convex becoming nearly plane or centrally

depressed, *dry*, polished, *even on the obtuse margin*, very red, almost shining, often darker in the centre. FLESH white, reddish under the cuticle, TASTE *acrid*. GILLS rather close, adnate, broad, unequal, some of them forked, white becoming yellowish with age. STEM hard, solid, white or red. Spores white, globose or subglobose, 8-10 micr.

Pileus 5-10 cm. broad; stem 5-7.5 cm. long, 12-20 mm. thick."

The *R. rubra Fr.* as known to Romell has a rather dry pileus, not polished, with a thin pellicle on the margin, and, like nearly all mature Russulas, slight striations on the margin when moist. In rainy weather only the margin is viscid and the surface layer is separable only for a short distance from the margin. Taste strongly acrid. This was the nearest to a red Russula of the Rigidae type as limited by Fries that I had ever seen. The designation of this group by Fries as "absolutely dry, lacking a pellicle" has in my opinion been taken in too rigid a sense. It is probable that the presence or absence of a pellicle is a relative matter, and that not too much stress must be laid upon it. A pellicle, or, perhaps better cuticle when it is adnate or not well differentiated, seems to be always present in a more or less degree, but disappears early on the disk because its development ceases early.

10. RUSSULA LEPIDA Fr.

Illustrations: Hard's Mushrooms. 1908. P. 188, Fig. 149. Atkinson's Mushrooms. 1900. Pl. 36, p. 126, Fig. 3.

PILEUS 6-10 cm. broad, fleshy, firm, convex then plano-depressed, margin even, *dry*, subvelvety, bright red or dark purple, disk paler or subalutaceus. FLESH compact, cheesy, white. GILLS *thick*, subdistant, white *at length strawcolor* attenuated behind or adnexed, *forked*, interspaces venose. STEM 3-6 cm. long, 1.5-2 cm. thick, subequal, white almost *red-tinged* or one side red, base clavate or attenuate. SPORES *pale strawcolor* in mass, globose, echinulate, 8-9 micr. TASTE *mild*, but becoming slightly peppery after chewing. Odor pleasant.

In woods, southern Michigan. July.

The description given above is that of Bresadola, since I have not found enough specimens which could with certainty be referred under any description of *R. lepida*. Fries and the English authors emphasize the rimose-squamose character of the cap; they say gills are white, taste mild and colors of the cap blood-red with disk whitish. According to most American mushroom books, *R. lepida* is said to be very common everywhere. From present information it is rare in Michigan by any of the descriptions, and Peck who has had many years of opportunity reports it uncommon in New York state, and his plants do not have all of the Friesian characters. Fries placed this species under the tribe RIGIDAE, and his description seems to assume the complete absence of a pellicle. I am inclined to believe that all these Russulas have some kind of differentiated upper layer on the surface of the cap, at least when young. I saw no Russula in Sweden (except COMPACTAE) which could not be slightly peeled along the outer margin.

11. RUSSULA OCHROPHYLLA Pk.

(The ochre-gilled Russula.)

Illustrations: N. Y. State Memoir, 3. 1900. Pl. 54, p. 150, fig. 8-14.

PILEUS 5-10 cm. broad, firm, convex then plano-depressed, dry, unpolished, *even* on the margin, dark red or *purplish-red*, often darker on the centre.

Flesh white, red under the adnate cuticle. Gills *yellowish from the first*, becoming bright ochraceous-buff, dusted by the spores, subdistant, adnate, nearly entire, a few forked, interspaces venose. Stem 3.5-6.5 cm. long, 1-2 cm. thick, *reddish*, equal or subequal, solid or spongy within. Spores bright ochraceous-buff, globose, 10 micr. Taste *mild*. Odor not marked.

Found and reported in New York State and Wisconsin, and probably occurs in Michigan. The above is Peck's description. In his 50th report he says this species has the colors of *R. drimeia* Cke. figured by Cooke. (Ill. Pl. 1023.) according to these figures, *R. ochrophylla* corresponds in color to my *R. sericeoniteus*. Both species have a mild taste. Peck places his specise with the Rigidae, and its firm consistency along with the ochraceous-buff spores and reddish stem separate it from *R. sericeoniteus*. It is interesting to note that both American plants of this dark purple color have a distinct mild taste, while the four species of Europe, considered by some as one species, include acrid types only. Peck "separates *R. ochrophylla* from *R. alutacea* by its deep red color and even margin."

12. Russula borealis sp. Nov.

(The northern red Russula.)

Pileus 5-9 cm. broad, firm and rather compact, convex then plano-depressed, outine broadly elliptical, often with a sinus on one side, blood-red disk darker or color uniform and not fading, pellicle somewhat separable, hardly viscid, margin even or obscurely striate. Flesh white, red under the cuticle, not very thick. Gills *ochraceous*, subdistant or moderately close, *medium broad*, broader in front, narrowly adnate, rather distinct, edge often reddish anteriorly, equal, a few forked toward base, interspaces venose. Stem white and *tinged red* in places, *firm*, spongy-stuffed, thickened below, 5-7 cm. long, 1.5-2 cm. thick. Spores deep *ochraceous-yellow* in mass. Taste *mild*, sometimes slightly and tardily acrid. Odor none.

Solitary. In mixed woods of hemlock, yellow-birch and hard maple, in the northern peninsula. Huron Mts., Marquette and Munising. August.

Russula alutacea is usually larger, stouter, the cap dull or sordid red, and with broader gills. *Russula ochrophylla* occurs in oak woods, has "buff spores, dusted" on yellow gills, and has a violaceous-purple or purple-red cap. Peck saw our plant but did not refer it to either species. This species and *R. alutacea* show the futility of using the striations on the margin of the cap as an important character to distinguish subgenera. A true pellicle is present in both and is often quite easily separated especially on the margin, and this with the character of the gills connects them very closely with the Fragiles. *R. Linnaei*, which is not well known in Europe, looks like it according to Cooke's figures, but has white gills and spores.

12. Russula alutacea Fr.

(The tan-gilled Russula.)

Illustrations: Hard's Mushrooms. 1908. P. 186, fig. 148. Atkinson's Mushrooms. 1900. Pl. 36, p. 126, fig. 2.

Pileus 8-15 cm. broad, *large*, *firm*, convex then plano-depressed, with *dull colors*, dark reddish-purple, sordid red, sometimes mixed with other shades, but the reddish color predominating, with *separable pellicle*, smooth, somewhat viscid in wet weather, pruinose or subgranulose in dry weather, margin even or later rather tubercular-striate. Flesh white, thick on disk,

Gills *ochraceous from the beginning*, deeper ochraceous to tan-colored when mature, *rather broad*, thick, *subdistant*, broader in front, rounded adnexed, of *equal* length. Stem 7-10 cm. long, 3-4 cm. thick, very *firm*, *stout*, solid, *tinged red* or entirely white, subequal or ventricose, almost even. Spores ochraceous-yellow to alutaceous, subglobose, 9-11 micr. Taste *mild*. Odor none, or pleasant.

Usually solitary and rather late. Oak and maple woods of southern Michigan. Not very common. August and September.

As limited above, no bright or shining red forms are admitted from our territory. This species and *R. integra* have been the receptacle for a good many reddish species with ochraceous gills, and even experienced mycologists cannot agree on their identification. I have kept this name for a large, solitary, often late plant, with firm or hard consistency and dull, dark red and purplish cap, with truly ochraceous gills and spores. *R. integra* has cream-colored or at least paler spores and is more fragile and often grows in troops. The descriptions of this and *R. ochrophylla* run close together. Cooke's Ill. of *R. alutacea* fit our plants well.

14. Russula mariae Pk.

(Mary's Russula.)

Illustrations: N. Y. State Mus. Bull. 75. 1903. Pl. 85, fig. 1-8.

Pileus 2-7 cm. broad, *firm*, convex to plano-depressed, with an adnate continuous pellicle, separable on margin, broadly viscid to dry, *not striate*, when fresh, opaque or dull, hardly viscid, usually dry, dark blood-red, purple or sometimes pink-red, *glaucous*. Flesh white, pink under the cuticle, rather firm. Gills whitish then yellowish or pale ochraceous, close, distinct, rather narrow, broader toward front, narrowly adnate, mostly equal, few forked. Stem reddish, purplish or white, equal or tapering downward, spongy-stuffed, *rather short*, even or obscurely wrinkled, 2-5 cm. long, 1-5. cm. thick. Spores pale yellow to ochraceous-yellow, globose, 7.5 micr. Taste *mild or tardily acrid*. Odor none.

Gregarious. Woods or open places under trees. Probably thruout the state July to September.

I have included here all our red forms with *glaucous*, rather firm and somewhat dry pileus. A medium sized plant grows around Ann Arbor with gills more ochraceous than the type, with flesh tardily acrid and with white stem; but because of its distinct whitish bloom on the cap, it is included. A small, pale red, subacrid form grew under pines at Marquette on the sand; its cap was glaucous, and it is also included. *R. Mariae* is to be distinguished from *R. veternosa* and *R. tenuiceps* by its taste, firmness, short stem and even glaucous pileus. The glaucous-pruinate cap is sometimes yellow-spotted on the disk.

15. Russula xerampelina Fr.

(The variegated Russula.)

Pileus 5-10 cm. broad, *firm*, convex then plano-depressed, dry or very slightly viscid in wet weather, pellicle hardly separable, not striate on margin, surface glabrous or subpruinose, purplish-red to purplish-olive, disk olivaceous, variegated. Flesh compact, whitish then dingy. Gills *creamy-white* to creamy-yellowish, then sordid, rather close, adnexed, moderately broad thruout, thickish, often forked, shorter ones usually intermingled, interspaces venose. Stem white or *rosy-tinged*, soon dingy olivaceous-yellowish

where handled, 5-7 cm. long, 1.5-2.5 cm. thick, firm, subventricose or equal, spongy-stuffed, even or obscurely wrinkled, *changing* where bruised *to dirty ochraceous-brown*. Spores creamy-yellowish, globose, echinulate, 9-10 mier. Taste *mild*. Odor *disagreeable with age* or when drying.

Scattered. Hemlock and coniferous or mixed woods of the northern peninsula. July and August.

This has usually been referred to *R. olivacea Fr.* in this country. In Europe, *R. olivacea* is a very much debated species. Fries' description requires truly yellow gills (luteis), and with this character it has seldom been found. Romell has never seen such a plant in Sweden and unites *R. olivacea* and *R. xerampelina* under the name *R. graveolens*.* The series of color forms included under the last name is quite common about Stockholm, and as far as I could see it is the same as our northern Michigan species. I assume, then, that we can drop the name *R. olivacea* from our list of American Russulas, in which case our olive form goes into the present species.

Our plant is near *R. squalida Pk.* as the latter is diagnosed in this paper. It differs, however, from that species in the more firm consistency, in the stem being often reddish, and its habitat in coniferous regions. *R. squalida* is soft and flexible in age. A variety occurs in northern Michigan, whose flesh does not change when bruised, and which has forked, subdistant gills; the gills and spores are cream-color.

16. Russula squalida Pk. syn. R. atropurpurea Pk.)

(The squalid Russula.)

Pileus 7-11 cm. broad, convex then plano-depressed, firm, margin *even when young*, becoming slightly tubercular-striate in age, the pellicle continuous but rather adnate, not easily separable, subviscid in wet weather, *soon dry* and then *pruniose-velvety*, even, color varying from reddish-purple to pallid and mixed with olivaceous, tan or ochraceous, often shades of all these colors are seen in one cap, opaque and dull, not shining. Flesh white, thick on disk, rather thin elsewhere, grayish or grayish-purple under the cuticle. Gills white when young, later *creamy-yellow to ochraceous*, subdistant, becoming fragile, moderately broad, broadest toward the front, more or less forked toward base, few shorter ones, interspaces venose. Stem *white, changing to ochraceous when bruised* if fresh and young, when older becoming dirty-brown or ochraceous-brown where handled, equal and subcylindrical, rather long, 5-9 cm. by 1.5 cm. thick, glabrous, spongy-stuffed, obscurely rivulose. Spores ochraceous to buff, globose, 7.5-10 mier. Taste *mild*. Odor *unpleasant*, very characteristic when plants are old or drying.

Solitary or gregarious. Hemlock and maple woods in the north, oak and maple woods in southern Michigan. July, August and September.

This is our early, abundant Russula about Ann Arbor. It occurs in great quantities during July if the weather is favorable and only sparingly later. Once recognized by its odor and changeable flesh, its many color disguises are not as deceptive as they at first seem. The colors run into each other in a rather definite way, so that the general effect to the observer, after he has compared many individuals, is quite characteristic for the species. Hundreds of individuals were examined about Ann Arbor and all had white stems, never red. When old the effect of the whole plant is that of dinginess Altho the above description extends beyond the limits allowed by Peck's description, it is doubtless his species. Originally it included only the purple

*Lindblad's Svampbok; l. c.

or dark red forms and was called *R. atropurpurea Pk.* but since this name was preempted, he changed it to *R. squalida.* It seems close to the preceding.

17. Russula flavida Frost.

(The white-gilled yellow Russula.)

Illustrations: N. Y. State Mus. Bull. 105. 1906. Pl. 97, p. 38, fig. 1-6.

This striking species with yellow cap and stem and the gills white, has not been reported within the state. It no doubt occurs, as it is a northern species and I append the description as given by Peck.

Pileus 5-7.5 cm. broad, firm, convex, becoming nearly plane or centrally depressed, dry, frequently sprinkled with minute mealy yellowish particles, specially on the margin, pale yellow, sometimes brighter yellow or orange in the centre. Flesh white. Gills rather thick, moderately close, entire or nearly so, adnate, *white.* Stem equal or slightly tapering upward, solid, sometimes becoming spongy within, occasionally cavernous, colored like the pileus or a little paler, sometimes brighter at the base, 3-7.5 cm. long, 8-15 mm. thick. Spores yellowish, subglobose, 7-8 micr. Taste mild.

18. Russula virescens (Schaeff.) Fr.

(The Greenish Russula.)

Illustrations: N. Y. State Mus. Rep. 48, Bot. edition. 1894. Pl. 31, p. 189, fig. 1-8. Atkinson's Mushrooms. 1900. Pl. 36, p. 126, fig. 1. McIlvaine American Fungi, 1900. Pl. 44, p. 184, fig. 6. Marshall's Mushroom Book, 1902. P. 68.

Pileus 5-12 cm. broad, at the very first globose, soon convex and expanded, often somewhat depressed on disk, firm, *dry*, as if velvety, the surface (especially the disk) broken into many floccose or pulverulent *areas or patches*, *green* or grayish green, the margin *not striate* or rarely so, a cuticle scarcely distinguishable or separable. Fresh white. Gills *white*, rather close, narrowed toward the stem, almost or entirely free, few shorter or forked. Stem 3-7 cm. long, 1-2 cm. thick, white, firm, equal or subequal, solid or spongy. Spores white, subglobose, 6-8 micr. Taste *mild.* Odor none.

Oak and maple or mixed woods, probably thruout the state. Occasional. July and August.

Under this name there was included in this country for quite a time a more common form with viscid striate cap which has been segregated by Peck under the name of *R. crustosa.* The two seem to run into each other at times, but Peck distinguishes the pileus of *R. crustosa* "by its smooth, not warty centre, its paler color and usually striate margin." It is also distinctly viscid when young, but this depends considerably on the weather conditions. It might be confused with green specimens of *R. variata*, whose surface is sometimes areolate, but the gills of *R. virescens* are not as pure white, are not decurrent nor much forked, and the taste is mild.

19. Russula crustosa Pk.

(The crusty Russula.)

Illustrations: Hard's Mushrooms, 1908. P. 189, fig. 150. N. Y. State Mus. Bull. 67, 1903. Pl. 84, p. 45, fig. 1-7.

Pileus 5-12 cm. broad, firm, convex then expanded and depressed in the centre, surface cracked except on disk, the *areas crustlike*, sordid cream-color

dirty brownish or ochraceous, usually tinged with olive or green, *viscid* when young or moist, especially on the disk, *striate on margin* when mature. Flesh white. Gills *dull white* becoming somewhat dingy cream color in age, rather broad in front, narrowed toward the stem, adnexed or free, *thick, distinct*, not crowded, rather brittle, few forked, few short. Stem 3-6 cm. long, 1-2.5 cm. thick, short, stout, spongy-stuffed, subequal or ventricose, white. Spores white, subglobose, 8-10 micr. Taste *mild*. Odor none.

Scattered or gregarious. Oak and maple woods in southern Michigan. July to September. Common.

This is near to *R. virescens*, and is apparently much more common. It seems to be still referred to *R. virescens* by some authors, altho in that case the Friesian description will have to be modified to include it. The figure in Hard's book is doubtless this species instead of *R. virescens* as labeled.

SECTION B.

Margin of pileus thin, at first incurved. Gills attenuate at both ends, or broad or narrow thruout.

20. Russula variata Bann.

(The variable Russula.)

Illustrations: N. Y. State Mus. Voll. 105, 1905. Pl. 101, p. 41, fig. 1-5.

Pileus 5-12 cm. broad, fleshy, firm, convex then depressed to subinfundibuliform, viscid, *not striate*, purplish or *deep rose pink when young*, later variegated with olive or dark umber or sometimes *greenish* with only a trace of *purple*, opaque and reticulate-wrinkled under lens, the thin pellicle slightly separable on the thin margin, with a subsilky or dull lustre when dry. Flesh white, firm, cheesy, tinged grayish under pellicle. Gills shining and *persistently white*, adnato-decurrent, thin, *rather crowded*, narrowed at both ends, not broad, *subdichotomously forked*, interspaces venose. Stem 4-7 cm. long, 1-3 cm. thick, white, firm, solid, equal or subequal, sometimes tapering downward, even. Spores *white in mass*, subglobose, 7-10 micr. Taste *mild to tardily slightly acrid* or slightly astringent. Odor none.

Gregarious. Under conifers at Marquette, in decidious woods about Ann Arbor. July, August and September.

Superficially nearest to the descriptions of *R. furcata* and *R. virescens*. Our plant has usually been referred to *R. furcata*, but this has no purple tints according to European authors. When one finds single old plants with much green, it is quite difficult to distinguish it from *R. virescens;* it is to be separated by its dichotomously forked gills which are slightly decurrent and more persistently white, and by the slight acridity. The cuticle is sometimes cracked toward the margin as in *R. virescens*, but its margin is at first incurved while in *R. virescens* it is straight on the stem. Peck says it has a good flavor after cooking, which destroys the slight acrid taste.

21. Russula furcata (Pers.) Fr.

(The forked Russula.)

The plants in this country which used to be referred to *R. furcata* seem to have found a more appropriate resting place in Miss Banning's recent species *R. variata*. Whether we have the true *R. furcata* in Michigan is very uncertain; indeed the European mycologists are just as uncertain concerning

its occurrence with them. In a recent article M. Peltereau* has summarized the opinions of the various authorities, and comes to the conclusion that the form which is usually referred to *R. furcata* in Europe, is rare and is really a variety of *R. cyanoxantha*. The Swedes where Fries lived do not know it. All agree that it is rare, and has no purple or reddish tints. Peck reports it in only one locality and distinguishes it from *R. variata* by its color, subdistant and thick gills, and mild taste. Authors differ as to whether the taste is mild, acrid, bitterish or poisonous. It differs from *R. virescens* according to the descriptions, in its margin being at first involute, the cuticle not breaking up into patches, and by its more persistantly white gills.

22. Russula cyanoxantha (Schaeff.) Fr.

(The yellowish-blue Russula.)

Illustrations: McIlvaine's American Fungi, 1900. P. 184, fig. 1.

Pileus 5-10 cm. broad, *firm*, convex then expanded and depressed in the centre or subinfundibuliform, *disk dingy white tinged rose-pink*, elsewhere dark bluish-purple or lilac, *viscid*, pellicle thin and adnate but separable on the margin, *even*, or substriate only near the edge, surface somewhat wrinkled or streaked. Flesh white, compact, purplish or white under pellicle. Gills *white*, a few forked toward base, few shorter, moderately broad, not very distant, narrow behind, interspaces veined. Stem 6-9 cm. long, 1-2 cm. thick, white, subequal, spongy-stuffed, sometimes becoming cavernous and compressed, glabrous, even or obscurely wrinkled. Spores *white in mass*. Taste *mild*. Odor none.

Scattered or gregarious. Maple and birch, or mixed woods of northern Michigan, oak and maple woods of the southern part. July and August.

The above description applies to a definite form which occurs in Michigan. Some of its characters do not agree with the species as understood by Romell, Peltereau and others, whose typical plant has creamy-white gills and spores. It does, however, agree with Peck's conception, though within narrow limits. The plant occurs quite often, especially in the north, and is quite constant. Peltereau thinks *R. furcata* is only a form of *R. cyanoxantha*, and that the published plates of European mycologists of *R. furcata* apply to *R. cyanoxantha*. He then proceeds to give three varieties of *R. cyanoxantha*, of which var. A. is close to our plant except that the color of the spores differ. The European authors also find yellowish tints on the disk. It seems almost impossible to obtain a clear idea of the exact relationships of *R. furcata*, *R. cyanoxantha*, and *R. variata*. We have some forms in Michigan which seem to be intermediate, and this produces no end of confusion. Our plant agrees pretty well with the Fresian description, and I perfer to limit it to that species.

23. Russula vesca Fr.

(The poor Russula.)

Pileus 3-6 cm. broad, fleshy, firm, convex then expanded and depressed in the centre, viscid soon dry, more or less rugulose or wrinkled, reddish, *pale livid-pink*, or sordid flesh-red, becoming paler, cuticle thin and disappearing, *not quite reaching the edge of the pileus* so that a narrow white exposed margin results, margin even and spreading. Flesh white. Gills white, thin,

*Peltereau } See also: M. Barbier } Bull. trimestrial de la Societé Mycologigue de France, Vol. 24.

at length *stained* lurid-brownish or rusty, close, moderately narrow, adnate, forked or anastomosing at base. STEM white, obscurely rivulose, *hard* and compact, subequal, solid, 3.5-4.5 cm. long, 1.5 cm. thick, often discolored by yellowish-rusty stains. SPORES *white in mass*, subglobose, minutely echinulate, 7-8 micr. TASTE *mild*. Odor none.

Only a few doubtful collections have been made in southern Michigan. The above description is taken from my notes of the Swedish plant as known to Romell, and agrees mostly with that of Bresadola. Most modern mycologists consider the Friesian "rugulose-reticulate" character of the stem as too uncertain to be practicable. The important characters are: The hard consistancy, the wrinkled, rarely "cutefracta" surface of the cap, the cuticle not reaching to margin of the cap, and the gills discolored in spots. The cuticle apparently discontinues to grow so that the surface of the expanding pileus may become somewhat areolate cracked and the margin naked.

The species does not seem to be known with definiteness to American authors, and Peltereau says of the European situation that "here is a plant which has been the cause of very different interpretations, and one could write a volume on its vicissitudes." I believe it best to follow the interpretation of Romell who is supported by Prof. von Post, formerly a pupil of Fries and his collaborator as artist of many of the Friesian figures now located in the Museum in Stockholm.

RUSSULA LILACEA Quel.

The plants referred here were in all respects like specimens found nea Stockholm, and referred by Romell to *R. lilacea*. The description follows:

PILEUS *firm*, convex then subexpanded to subumbilicate, 4-8 cm. broad, dull or dark lilac-flesh color, darker on disk, radiately rugulose, margin even, pellicle adnate or but slightly separable extending to margin, viscid when young or moist; flesh white. GILLS adnate, sometimes slightly decurrent, white or whitish, some shorter, occasionally forked, narrow, *close*, plane. STEM white or reddish, rigid, solid becoming spongy, slightly rugulose, equal, 4-5 cm. long, 8-10 mm. thick. SPORES whitish. Taste *mild*.

Mixed woods in northern Michigan, oak etc. in the south. Aug. Quelet describes the gills as "distant, adnexed, ventricose, and subserrate". Our plant has close, narrow, nonventricose gills and in this respect is nearer *R. vesca* than *R. lilacea Quel.*, which Massee has made a variety of it. Furthermore Quelet says *R. lilacea* has a fragile pileus, while in our plants it is firm.

24. RUSSULA AERUGINEA Lindb.

(The verdigris-green Russula.)

PILEUS 5-8 cm. broad, *medium firm or sub-fragile*, convex to expanded, somewhat depressed on disk, *dull green* or *dark green*, sometimes with an umber tinge, with a thin, slightly separable, subviscid pellicle when moist, subshining or dull and subpulverulent or pruinose-velvety when dry, slightly striate on margin. FLESH white, sometimes ashy under cuticle, thick on disk, thin at margin. GILLS white, then pale cream color becoming *dingy with age*, subdistant to close, firm and distinct, broader in front, narrowed behind, almost free, few shorter, somewhat forked at stem, interspaces venose. STEM 4-5 cm. long, 1 cm. thick, white, subequal or tapering downward, glabrous, spongy, stuffed, even, firm. SPORES *creamy-white*, or whitish, globose, 6-7 micr. TASTE *mild*. Odor none.

Solitary or gregarious. In coniferous or mixed woods of the northern peninsula. Rare. July, August and September.

The above description agrees fairly well with that of the *R. aeruginea* found about Stockholm. Fries refers to the gills as shining white (*candidae*), but the gills of the Swedish plants like ours soon become dingy white and are often discolored in the middle. Their plants grow larger, have a more glabrous pileus, and are more abundant, but are evidently the same species. It is placed among the FRAGILES in Hymen. Europ. but it is quite firm as a rule, and our specimens were at first referred to *R. heterophylla Fr.*, a species concerning which the European mycologists seem at present to be somewhat uncertain.

25. RUSSULA OLIVASCENS Fr.

(The pale olive Russula.)

PILEUS 5-8 cm. broad, *rather firm,* convex then plano-depressed or umbilicate, olivaceous on disk, paler on margin, *no purple shades* present, pruinose, opaque, margin *even* or at length slightly tubercular-striate, pellicle slightly separable, hardly ever viscid. FLESH white, unchangeable, thin on margin. GILLS *cream color*, medium close, moderately broad, narrowed behind and adnexed, broader in front, thin, few shorter, few forked. STEM 5-7 cm. long, dull white, rather stout, firm, spongy-stuffed, sometimes compressed, subequal, sometimes abruptly short attenuate at base, obscurely reticulate. SPORES *creamy-yellow*, subglobose, echinulate, 7-9 micr. TASTE *mild*. Odor none.

Gregarious. Hemlock and mixed swamp, Sault Ste. Marie, oak and maple woods at Ann Arbor. July. Infrequent.

This species does not seem to be known to the present Swedish mycologists. The *R. olivascens* of Persoon is usually joined with *R. alutacea*. Peck reports our plant from N. Y., and Denniston from Wisconsin. If the color of gills and spores are significant, then our plant is hardly Persoon's species and cannot be joined to *R. alutacea*. Close to the preceding.

26. RUSSULA SORORIA Fr.

(The sister Russula.)

PILEUS 3-6 cm. broad, rather firm, convex then subexpanded, viscid when moist, margin substriate when mature, pellicle somewhat separable along margin, *grey*, olivaceous-brown or grayish-brown. FLESH white, unchanged. GILLS narrow, subdistant, distinct, white for a time, then discolored, adnate shorter ones intermingled, rarely forked, interspaces venose. STEM 2.5-5 cm. long, 1-2 cm. thick, white, not becoming cinereous, short, spongy-stuffed, SPORES *white*. TASTE *acrid*. Odor none.

Solitary. Woods in southern Michigan. August and September.

This species used to be placed under *R. consobrina*. We have a form with colors much the same, the cap and base of stem rusty-blotched, but gills and spores straw-yellow. It is appended for the present to this species, as its position is uncertain.

27. RUSSULA CONSOBRINA Fr.

This species has not been reported for the state. It is characterized by its acrid taste, even margin and uniform grayish color on the cap, the flesh of the stem turning cinereous with age and the white spores.

28. Russula pulverulenta Pk.

(The mealy-dotted Russula.)

Pileus 3-5 cm. broad, rather rigid, *then fragile*, rather thin, irregularly convex, soon centrally depressed or subumbilicate, at first even on margin, tubercular-striate when expended, the viscid pellicle separable on margin, ochraleucus (Sacc.)|then grayish-brown, *surface dotted* by small, numerous, *pale yellow* somewhat *mealy scales* or patches. Flesh white with loose tissue. Gills white, unchanged, rather close, broadest in front, few forked at base, adnate, interspaces veiny. Stem 4-5 cm. long, 1-1½ cm. thick, subequal or irregularly enlarged, stained or *dotted with sulphur- yellow granules*, white elsewhere, spongy-stuffed *becoming cavernous*, rigid-fragile. Spores *white in mass*, globose, 6-8 micr. Taste and odor somewhat disagreeable.

Gregarious. On lawns, roadsides or margin of woods among grass, etc. July to September. Southern Michigan.

I have referred here a Russula which differs from the description of *R. pulverulenta Pk.* in its striate pileus, less foetid odor, and from *R. granulata* in its yellow pulverulence on the stem. Since Peck's description was made from a single Michigan specimen, found by Longyear,* it is very probable that the striations did not show in his plant as is often the case in fresh young plants. I have ventured to amend the description from my own notes, as I believe my specimens to be the same plants as Longyear's. The yellow granules may possibly represent a primitive universal veil, since they occur mostly on the margin of the pileus in young plants. The habitat seems to be mostly in open grassy places.

29. Russula granulata Pk.

(The gramulated Russula.)

This is close to *R. foetens*, of which it was formerly a variety. It differs in the pileus being "rough with minute gramules or squamules," in its closer narrow gills and the absence of odor. It seems to have close affinities with *R. pulverulenta*. It is not yet with certainty reported for Michigan. The species reported in the lists, in the Report of the Michigan Academy, are probably *R. pulverulenta Pk.*

30. Russula pectinatoides Pk.

(The pectinata-like Russula.)

Illustrations: N. Y. Mus. Bull. 116, 1906. Pl. 105, fig. 6-10.

Pileus 3-7 cm. broad, rather firm *becoming fragile, thin*, convex, then plano-depressed, viscid when moist, covered by a thin separable pellicle, radiately rugose-striate on the margin, often halfway to the centre, or *strongly tubercular-striate*, dingy straw color, brownish, yellowish-brown or umber-brown. Flesh white, thin, becoming fragile, slightly *ashy under the cuticle*, not changing. Gills whitish, close to subdistant, thin, distinct, equal, moderately broad, broadest in front, narrowed behind, often stained or broken halfway from stem, some forked at base. Stem white or dingy, subequal, glabrous, spongy-stuffed *then hollow*, even, 2-5 cm. long, .5 to 1 cm. thick. Spores whitish or creamy-white in mass, subglobose, 6-8 micr. diam. Taste mild or slightly and tardily acrid. Odor *not noticeable*.

*4th Rep., Mich. Acad. of Sci., p. 120.

Gregarious. Grassy places, lawns, groves and woods. Thruout the state. July and August.

Cooke's Illustrations of *R. pectinata* and *R. consobrina var. sororia* reminds one very much of the plant. Peck points out that it differs from these by its milder taste, adnate gills and grayish color under the cuticle. *R. subfoetens Smith* as known to Romell, also reminded me of this species. The color of *R. pectinatoides*, the long striations and the medium size are the best recognition marks in the field. It differs of course from *R. foetens* by lack of a strong odor. Whether the margin is at first incurved is nowhere noted.

31. Russula foetentula Pk.

(The small, ill-smelling Russula.)

Not found with certainty in our region, altho reported. It is distinguished from *R. foetens* by its closer gills and the colors given in the key. The odor is amygdaline. Spores *very pale yellow*. The character of the young margin is not given.

32. Russula foetens (Pers.) Fr.

(The ill-smelling Russula.)

Illustrations: Hard's Mushrooms, 1908. P. 185, fig. 147.

Pileus 7-12 cm. broad, fleshy, hard then fragile, *subglobose* then expanded and depressed, viscid when moist, thin margin at first incurved, *tubercular-sulcate* when expanded, yellowish or dingy ochraceous, pellicle adnate. Flesh thin, rigid but fragile, dingy white. Gills white, *at first exuding drops* of water, sordid when old or bruised, rather close, adnexed, few forked, interspaces venose, shorter ones present. Stem 4-6 cm. long, 1-2.5 cm. thick, whitish, short, stout, stuffed then cavernous. Spores *white* in mass, subglobose, 7.5-10 micr. Taste *acrid*. Odor *strongly amygdaline*, becoming foetid.

Gregarious. In mixed woods in the north; in oak, maple, etc., in southern Michigan. July, August and September.

The odor of the fresh young plant is like oil of bitter almonds or cherry bark; when old or decaying it becomes quite disagreeable. The margin of the young pileus is strongly incurved. Not edible.

FRAGILES. (RUSSULINA. Schroet. In sense of Earle.)

Pileus thin, fragile, the viscid pellicle continuous and quite separable, margin connivent, not incurved when young, usually strongly striate. The gills are of equal length, broader anteriorly, narrowed behind.

A. TASTE ACRID.

33. Russula emetica Fr.

(The emetic Russula.)

Illustrations: Atkinson's Mushrooms. 1900. Pl. 36, p. 126, fig. 4. McIlvaine's American Fungi, 1900. Pl. 44, p. 184, fig. 2. Hard's Mushrooms, 1908. P. 193, fig. 153. Marshall's The Mushroom Book, 1902. Pl. opp. p. 68.

Pileus 5-10 cm. broad, fleshy, soon *fragile*, convex to plano-depressed, *rosy to blood-red*, sometimes faded to white, pellicle separable, *margin strongly tubercular-striate* or even sulcate, viscid and shining. Flesh white, *red under the cuticle*. Gills pure *white*, subdistant or close, distinct, rather broad, equal, broadest toward front, narrowly adnexed or free, interspaces venose. Stem 4-7 cm. long, 1-2 cm. thick, white or tinged red, subequal, spongy-stuffed, even. Spores *white in mass*, globose, echinulate, 7.5-10 micr. Taste *very acrid*. Odor none.

Scattered or gregarious. On the ground or on debris of very rotten logs in woods. Thruout the state. July to October. Common.

The mycelium has been found to be attached to oak tree roots where it forms mycorrhiza. The very acrid taste gives it a bad reputation and it is avoided by mushroom-eaters. Some think it is harmless when thoroughly cooked. There are variations of habitat. It grows quite constantly on the crushed remains of wood or logs, where its white strings of mycelium are easily seen; here the gills are close. One form has been found growing in troops; such were found in a tamarack swamp in late October, growing on thick beds of sphagnum. They had developed somewhat differently as was to be expected. The stems were white, long and stout, narrower above and obsoletely wrinkled. The gills were subdistant. The taste was sharp but not as excruciating as that of the type. The disk of the pileus is glabrous and very viscid. It is a beautiful plant, apparently appearing late, it might be referred to as *var. gregaria*.

34. Russula rugulosa Pk.

(The rugulose Russula.)

Illustrations: N. Y. State Mus. Rep. 54, 1901. Pl. 72, p. 179, fig. 12-18.

Pileus 5-10 cm. or more broad, thin, fragile, convex then plano-depressed, dark rose-red, color sometimes thin, *surface* almost entirely *rugulose*, the rugae radiating somewhat, rather viscid, pellicle separable, margin at length distinctly tubercular-striate. Flesh thin, white, red under pellicle. Gills shining white, rather close, narrowly adnate, not very broad, broadest in front, few forked, equal, interspaces venose. Stem white, subequal, unchanged, glabrous, spongy-stuffed, 6-7 cm. long, 1-2 cm. thick. Spores *white in mass*, globose, echinulate, 8-9 micr. Taste tardily but very acrid.

In troops. Hemlock and mixed woods on the ground. August and September. Northern Michigan.

Differs from *R. emetica* in its acrid taste developing slowly, in the uneven and rather dull pileus and in the habit of appearing in troops on the ground. It was formerly referred to *R. emetica*, and is close to it.

35. Russula fragilis (Pers.) Fr.

(The fragile Russula.)

Illustrations: Hard's Mushrooms, 1908. P. 192, fig. 172.

Pileus 2.5-5 cm. broad, *very thin* and fragile, convex then plano-depressed with a thin viscid pellicle, tubercular-striate on the thin margin, glabrous, rather uniform rosy or *pale red*, sometimes faded or bleached to white. Flesh *white under the pellicle*, thin. Gills white, thin, close, crowded, adnexed, ventricose, moderately broad. Stem 2-3.5 cm. long, .5-1 cm. thick, white, spongy then hollow, equal, fragile. Spores *white in mass*, subglobose, 8-9 micr. Taste promptly and *very acrid*. Odor none.

Scattered. Woods thruout the state. Uncommon. July and August.

This species, as limited by the above description, is only distinguishable from *R. emetica* relatively, it is smaller, color paler, flesh thinner and more fragile, white under cuticle. It grows in somewhat dryer situations. It formerly included a number of so-called color varieties, but some of these have been segregated; such are *R. violacea Quel.* and *R. fallax Cke.* The *var. nivea* is a true color form.

36. Russula fallax (Schaeff.) Fr.

(The deceptive Russula.)

Pileus 3-7 cm. broad, *thin, fragile*, color incarnate or pale rose, the *disk* pale *olivaceous or livid*, sometimes darker or purplish, soon plane or slightly depressed on disk, quite viscid, margin striate and becoming elevated, surface faintly rugulose under lens. Flesh white. Gills white, unchanged, subdistant, attached by a point, *narrow*, edge even. Stem 3-4 cm. long, 6-10 cm. thick, pure white, cylindrical or compressed, equal, spongy-stuffed, soon hollow, longitudinally-wrinkled under lens. Spores *white in mass*, subglobose, 7.5 mier. Taste promptly and very acrid.

Solitary or gregarious. In sphagnum bogs, low mossy ground in woods, etc., often attached to sphagnum. Distributed thruout the state. Not rare. July, August and September.

This species differs in two important particulars from *R. fragilis*. The gills are subdistant, and the pileus is livid or olivaceous in the centre. It is very characteristic of the sphagnum Flora of the state. It has often been referred to *R. fragilis* as a variety; Saccardo erected it to a species.

37. Russula veternosa Fr.

(The drooping Russula.)

Pileus 5-7.5 cm. broad, convex then expanded, with a somewhat separable pellicle, *indistinctly striate* on margin, deep rose-red (like *R. emetica.*), viscid when moist. Flesh white, red under the cuticle. Gills white at first, *then straw-color or pale ochraceous*, narrow, adnate, close, broader in front, equal or few shorter, few forked, interspaces venose. Stem white, *never red*, equal or subequal, spongy-stuffed, somewhat slender, fragile, hollow, even, 1-1.5 cm. long, 1-1.5 cm. thick. Spores pale *yellowish-ochraceous*, subglobose, echinulate, 8-9 mier. Taste *very acrid.* Odor none.

Scattered or gregarious. Oak and maple woods of southern Michigan. July and August.

This represents a group of red Russulas with acrid taste, and gills varying cream-color, pale ochraceous or somewhat yellowish in the different forms. I have limited the name to those with white stem and a rather firm and hardly striate pileus, altho it may include several forms of which only the spore color has so far been distinguishable. The separable, viscid, distinct pellicle and rather fragile stem, relates it to the Fragiles. From *R. tenuiceps* it is separated by the less deep-ochraceous spores and gills, the firmer consistency of pileus and gills, and the uniform red color and even margin of the pileus.

38. Russula tenuiceps sp. nov.

(The thin-capped Russula.)

Pileus 7-12 cm. broad, thin, fragile, convex to expanded, the somewhat viscid pellicle easily separable, margin at first connivent *striate*, deep rosy-red or blood-red, sometimes white spotted or tinged with orange blotches, sometimes uniform red with or without minute rugae. Flesh white, red beneath the cuticle, *very fragile at maturity*. Gills white, then yellow-ochraceous, *crowded*, narrow, *fragile*, narrowly adnate to free, few forked, interspaces venose, equal, Stem fragile, white or rosy-tinged, spongy-stuffed, subequal or ventricose, obscurely rivulose, white within and unchanged, 5-9 cm. long, 2-2.5 cm. thick. Spores *yellow-ochraceous*, subglobose, 6-8 micr. echinulate. Taste acrid, sometimes tardily but very acrid. Odor not marked.

Gregarious. Mixed woods at Marquette, in oak and maple woods at Ann Arbor. July and August. Rather frequent.

As in *R. veternosa*, it is probable that several forms are represented here. The red Russulas are very troublesome, and we seem to have a considerable number of forms with acrid taste and yellowish to deep ochraceous gills, which can not be easily kept separate. All efforts to refer them to old species like *R. sardonia*, *R rugulosa*, *R. rosacea*, *etc.* failed repeatedly; the fragile flesh, and ochraceous almost alutaceous gills are too distinctive. The maturing of the spores is sometimes slow, and care must be taken to get a good spore print in these red species. All the collections which I have referred here showed red on some or all of the stems of each collection. Their edibility was not tried.

39. Russula aurantialutea sp. nov.

(The acrid yellow Russula.)

Pileus 5-10 cm. broad, *thin*, fragile, convex then plano-depressed, *yellow* (citron to luteus), *or with orange shades* intermingled especially on the margin, slightly tubercular-striate, pellicle viscid, shining and somewhat separable for some distance. Flesh *white*, thin toward the margin, *unchanged with age*. Gills *pale yellow*, close, or subdistant at the outer extremity, equal or a few shorter, narrowly adnate, seceding with age, broadest toward front, often forked at the base, rarely elsewhere, interspaces venose. Stem 4-8 cm. long, 1.5-2 cm. thick, white, flesh concolor and unchanged, subequal, glabrous, even, spongy-stuffed. Spores *ochraceous-yellow*, subglobose, 8-9 micr. Taste acrid in all its parts, often very acrid. Odor not noticeable.

Solitary or scattered. On debris or forest mould in hemlock or mixed woods of northern Michigan, in deciduous woods in the southern part of the state. July, August and September. Earlier in southern Michigan. Infrequent.

R. ochraleuca Fr. differs in having white to pallid gills and spores, and cinerescent stem; *R. granulosa Cke.* has white gills and spores and granular cap and stem. *R. fellea Fr.* has flesh ochraceous or straw-yellow, and the more firm pileus either straw or gilvous, and its gills exude watery drops; *R. claroflava Grove* has a cinerescent stem, gills white then lemon yellow tinged ochre; *R. ochracea Fr.* has a mild taste, and the flesh of cap, gills and stem is ochraceous; *R. simillima Pk.* has white spores and pale ochraceous pileus and stem; and *R. decolorans Fr.* has cinerescent flesh and is stouter.

Our species could be made an ecological variety of almost any of the above species, depending on the guess of the author who so interpreted it. The

fact seems to be that it differs in such points as are usually considered specific in this group, from all of them. Whether we call it a species or a variety makes no difference for purposes of identification, and its phylogenetic relationship can at present hardly be worked out.

40. Russula albidula Pk.

(The little white Russula.)

Pileus 2.5-5 cm. broad, *white*, broadly convex, glabrous, the pellicle *viscid* and separable when fresh, the margin even. Flesh white, subfragile. Gills white, rather crowded, adnexed, not broad, *of equal length*, some basifurcate, interspaces venose. Stem 2.5-4 cm. long, 8-12 mm. thick, white, equal, spongy-stuffed, even. Spores white in mass, subglobose, 7-10 micr. Taste acrid. Odor none. Solitary. In oak woods. Ann Arbor. July and August.

In dried specimens the pileus and gills are ochraceous to yellowish, the stem whitish. The taste and viscidity seem to be the only marked differences between this species and the other two white Russulas of Peck, *R. albida* and *R. albella*. All three are rather fragile, while the European *R. lactea* is a compact firm plant with thick, broad, distant gills. R. *emetica* has a white variety which is very acrid and fragile, but whose striations on the margin of the cap are like those of *R. emetica*.

B. TASTE MILD.

41. Russula albida Pk. Russula albella Pk.

(The whitish Russula.)

Pileus 3-6 cm. broad, *thin*, *fragile*, broadly convex to plane, slightly depressed in the centre, white or whitish, even or slightly striate on the margin, not shining. Flesh white, fragile. Gills white or whitish, thin, moderately close, entire, equal, not broad, broadest in front, rarely forked at base, adnate or subdecurrent. Stem 2.5-6 cm. long, white, subequal, glabrous, spongy-stuffed or solid. Spores about 8 micr. diam., *white*. Taste mild or *slightly bitterish*.

Solitary. Hemlock or mixed woods in the northern peninsula. July and August.

Peck's description of the two species named above differs in minor particulars from our plants. The pileus of *R. albida* has a viscid, separable pellicle, while that of *R. albella* is dry. *R. albida* is said to have a "slightly bitterish or unpleasant taste," while our plants were sometimes bitterish, sometimes tardily and slightly acrid. *R. albida* is described with stuffed or hollow stem; in one of my collections the stem was solid, in another it was spongy-stuffed. It is worth noting whether the spore prints are pure white or with yellow tinge; some of Peck's specimens of *R. albida* had spores with a faint yellowish tinge. In my specimens the whole plant is ochraceous when dried. As these species occur so seldom and far apart, it is difficult to obtain exact data with regard to their characters. *R. anomola Fr.* and *R. albidula* differ in the acrid taste.

42. Russula subdepallens Pk.

(The mild red Russula.)

Pileus 5-14 cm. broad, *fragile*, convex then plane and depressed, margin elevated in age, *bright rosy-red*, shading into yellowish blotches as if the red color were put over the yellow, disk paler in old specimens, disk dark-red in very young plants, with a thin separable, viscid pellicle, *tuberculär-striate* on margin, obscurely wrinkled elsewhere. Flesh white, rosy under the cuticle, becoming slightly cinereous, *very fragile*. Gills *white*, broad in front, narrowed behind, adnate, subdistant, few forked, interspaces venose. Stem white, spongy-stuffed, rather stout, 4-10 cm. long, 1-3 cm. thick, subequal. Spores *white in mass*, globose, echinulate, 7.5-8 micr. Taste mild. Odor none.

Gregarious. In woods of maple, yellow birch and hemlock of northern Michigan. August.

Found in a number of places in considerable abundance. The fragile character, especially of the gills, is very marked, and the mild taste, white gills, and red cap help to distinguish it. The flesh does not turn so strongly ashy as in Peck's plants, and this character did not seem to be always noticeable. It is distinguished from *R. purpurina*, the brilliant-red Russula by its gregarious habit, size and less viscid cap; also the gills are not crenulate. Our specimens had the stature and appearance of *R. rugulosa* and *R. emetica var. gregaria*. Peck's plants were found in Penna. by Dr. Herbst, and reported but once; the species is not included in Peck's N. Y. monograph. Our plant has so far been limited to the north.

43. Russula purpurina Quel. and Schulz.

(The crenulate-gilled Russula.)

Illustrations: Hard's Mushrooms, 1908. P. 196, fig. 176. McIlvaine's American Fungi. Pl. 45a, p. 188.

Pileus 3-7 cm. broad, fragile, *viscid*, usually very viscid, subglobose then expanded and slightly depressed at the disk, *brilliant rosy-red* to blood-red or even darker, pellicle somewhat separable, margin thin but *not striate* except when fully expanded, surface when dry as if with a bloom. Flesh white, red under the cuticle, thin, fragile, unchangeable. Gills *white*, later dingy-white or "yellowish," medium close to subdistant, adnexed, not broad, broadest in front, mostly equal, few or none forked, interspaces sometimes venose, *edge floccose-crenulate*. Stem rather long, 5-8 cm., 8-12 mm. thick, sprinkled rosy-pink, equal or subequal, spongy-stuffed, fragile but rather soft. Spores *white in mass*, globose, 8-10 micr. Taste mild. Odor none.

Solitary or scattered. In mixed or maple-birch woods of the northern peninsula. Infrequent. August and September.

Distinguished by its brilliant-red, viscid cap, small to medium size, mild taste and white crenulate gills and spores. Peck also notes the floccose-crenulate edge of the gills, which is due to cystidia. It differs from *R. Mariae* in the above characters. *R. uncialis*, *R. sericeonitens* and *R. subdepallens* are the only others of the Fragiles group with mild taste, red cap and white spores. From *R. uncialis* it differs by the deep color, character of gills and habitat. *R. sericeonitens* is hardly viscid and becomes silky-shining; it has a different stature and color.

44. Russula uncialis Pk.

(The inch-wide Russula.)

Illustrations: N. Y. State Mus. Bull. 116. Pl. 107, fig. 7-12.

Pileus 2-5 cm. *broad*, thin, rather fragile, convex then expanded-depressed, *pink* or *bright flesh-color*, unicolorous, the rather adnate pellicle slightly separable, slightly viscid when moist, pruinose and pulverulent when dry, margin not striate till old. Flesh white, pink under the pellicle, unchanged. Gills pure *white*, hardly changed, *rather broad*, broadest in front, narrowed behind and adnate, subdistant or moderately close, distinct, entire on edge, few forked, interspaces venose. Stem white, rarely tinged pink, rather short, 1-3.5 cm. long, 4-10 mm. thick, spongy-stuffed, equal, glabrous. Spores *white in mass*, subglobose, echinulate, 7-8 micr. Taste mild. Odor none.

Gregarious. In oak woods of southern Michigan. July and August. Quite common in places.

The persistently white gills and spores, the mild taste, uniform pink color and size, distinguishes this Russula. It is sometimes more than an inch in width.

45. Russula sericeonitens sp. nov.

(The silky-shining Russula.)

Pileus 4-6 cm. broad, very *regular*, rather thin, convex then plano-depressed, *dark violet-purple* or dark blood-red tinted purplish, disk sometimes livid blackish the *separable pellicle* slightly viscid when moist, not striate or substriate in age, surface with a silky sheen. Flesh white, thin on margin, unchanged, purplish under the pellicle. Gills *white*, subdistant or medium close, becoming flaccid, moderately broad, broad in front, narrowed behind, dry, equal, few forked near base, interspaces venose. Stem white, equal or thickened at apex, spongy within, unchanged, glabrous, even or obscurely rivulose, 3-5.5 cm. long, 1 cm. thick. Spores *white in mass*, globose, echinulate, 6-7.5 micr. Taste *mild*. Odor none.

Usually solitary. In mixed woods of hemlock, maple and yellow birch in northern Michigan. July and August. Not uncommon.

Its thin pileus is *flexible* at maturity. The *silky sheen* and regular pileus are quite characteristic. The cap has the color of Cooke's figures of *R. Queletii Fr.*, *R. drimeia Cke.* and *R. purpurea Gill.* These three, including *R. expallens Gill.*, have been placed together by some modern authors as one species, characterized by "a pruniose, violaceus, decolorate stem, and very sharp taste." The taste is said to be so peppery that even when the color is washed by rains they can be recognized by this character. All of the four have violet or reddish on the stem. Our specimens all had a white stem and an impeachable mild taste. Those who place the above four species together under one, on the ground that the difference in the color of the gills and spores is not sufficient distinction, would probably also include our species by neglecting the difference in taste. With our present knowledge, it is however, necessary to keep it distinct.

46. Russula integra Fr.

(The entire Russula.)

Pileus 5-10 cm. broad, firm, *soon fragile*, discoid, convex or campanulate then plano-depressed covered with a *viscid separable pellicle*, thin on the mar-

gin at length, *coarsely tubercular-striate*, variable in the color of different plants, *colors dingy or sordid*, from buff through to reddish-brown and dark dull red, *fading*. Flesh white, not changing. Gills *white at first*, then creamy-yellow to buff-ochraceous, not strongly ochre, *broad, distinct*, equal, nearly free. Stem white, unchanged, *never red*, soon quite fragile, conic or short-clavate at first, then subequal or ventricose, spongy-stuffed, even. Spores *creamy-yellow to pale ochraceous*. Taste mild. Odor none.

Gregarious. In woods, probably thruout the state. July and August. Not common.

This species is a sort of clearing house for various colored Russulas with broad, pale ochraceous gills and mild taste, especially reddish forms. I have given Fries' description above, supplemented for the most part from notes of my own collections about Stockholm. Romell* describes the cap as "brown, blackish-brown, reddish-brown, dark red, violaceus, yellow or greenish, either unicolorous or with whitish or yellowish spots." I myself, saw only the dirty reddish-brown, dark dull red, and sordid-buff forms at Stockholm. In favorable weather or situations, they occur in troops, and seem very common in Sweden. It is a question with me whether we have the Swedish species at all. Peck says they are rare in N. Y. state. The Europeans do not agree among themselves as to this species, but there seems to be a fair unanimity that the "dusting" of the gills by the spores is too deceptive for practical use in identification. *R. integra* is to be separated from *R. alutacea* by its gills being white at first, by the white fragile stem the paler spores and more striate pileus; under certian conditions these two species are hardly distinguishable.

Several varieties have been described and, as Fries pointed out long ago, it would be easy to segregate new species from the mass of plants usually referred here. The collections referred to this species from Michigan do not all look alike in every respect, either in color of pileus nor in shade of spore-color, and in this respect resemble our acrid species with ochraceous spores. There seems, however, no other place to deposit them, so they are called "forms" of *R. integra*. They all have reddish, thin, striate caps, fading in color, a separable pellicle and white stem, broad and subdistant gills, and cream to pale ochraceous spores; and the taste is mild, or in some cases slightly astringent or slightly and tardily acrid. The latter forms may be separable when better understood.

47. Russula puellaris Pk.

(The youthful Russula.)

Pileus 2-4 cm. broad, *very thin*, convex then plano-depressed, viscid, *tubercular-striate* on the margin, livid-purplish or livid-brownish, then sometimes yellowish. Flesh white at first, soon watery subtranslucent, fragile. Gills pallid white to pale yellow, watery honey-colored in age, equal, thin subventricose, narrowed behind and adnexed, interspaces venose. Stem whitish, then *watery honey-colored toward base*, spongy-stuffed soon cavernous, soft and fragile, subequal or subclavate at base, 4-5 cm. long, 7-10 mm. thick. Spores subglobose, echinulate, *pale yellow*, 6-8 micr. Taste mild or slightly acrid. Odor none.

Found in low, moist places in conifer or mixed woods of Europe. It has not yet been reported from Michigan with certainty. I have given Bresadola's description as that of a typical plant, and verified it by notes of the

*Lindblad's Svampbok: l. c.

Stockholm plants. I have not seen the typical Swedish plant in this country, and Peck's specimens were evidently not typical, as he says no yellowish stains occur in the stem. The stem soon becomes soft and then develops this characteristic translucent light yellowish color.

Several varieties occur in Europe without the characteristic stem, and our forms can perhaps be referred to them. *R. sphagnophila* (which see), could be considered as a *var.* of *R. puellaris*. Peck refers to *R. puellaris var. intensior Cke.*, a form with white stem, deep purple cap and mild taste, which has also been found in Michigan.

48. Russula sphagnophila sp. nov.

(The sphagnum-loving Russula.)

Pileus 2-4.5 cm. broad, *very fragile*, convex, *umbonate*, margin at length elevated and disk depressed and purplish-red or rosy-red, the space between the umbo and the margin pale olive-brown, covered by a viscous pellicle glabrous, margin slightly striate. Flesh reddish under the cuticle and under the surface of stem, fragile. Gills white then pale ochraceous, narrow, adnate-decurrent, rather close, narrowed toward both ends, few forked here and there. Stem *rosy colored*, usually ventricose or irregularly swollen, spongy-stuffed *then cavernous*, very fragile, rivulose-uneven, 4-5 cm. long, 7-12 mm. thick. Spores cream-color globose, echinulate, 6-7 micr. Taste *mild*.

Scattered. On sphagnum, in swamps. Cold Spring Harbor. August and September.

Whole plant very fragile, always with an umbo, subpellucid and rosy stem, and pale gills. The only other Russula with an umbo, known to me, is *R. caerulea Pers.*, which differs in color and habitat. The red color rubs off on paper when moist. In some points it is near *R. roseipes*, in others near *R. Mariae*. It it nearest *R. puellaris*, and might perhaps be referred to it as a variety, but without settling anything as to its origin.

49. Russula roseipes (Sec.) Bres.

(The rosy-stemmed Russula.)

Illustrations: Hard's Mushrooms, 1908. P. 191, fig. 151.

Pileus 2.5-5 cm. broad, *thin*, *fragile*, convex then plano-depressed, with a viscid, separable pellicle, margin tubercular-striate when mature, soon dry, *rosy-red or flesh-red*, disk tending to ochre-yellowish. Flesh white, thin, unchanged. Gills soon truly *ochraceous*, subdistant, mostly equal, broadest in front, ventricose, narrowly adnate or almost free, few forked, interspaces venose. Stem white and *rosy-sprinkled*, stuffed then cavernous, equal or tapering upward, even, 2.5-5 cm. long, 5-12 mm. thick. Spores *ochraceous*, globose, echinulate, 8-10 micr. Taste mild. Odor none or pleasant.

Solitary or scattered. In mixed woods, but usually under conifers. Only found in the northern part of the state. July and August.

A middle-sized to small plant, fragile, and with a rosy mealiness on the stem. This last is quite characteristic of the species. It occurs under spruces and balsams in moist places. It is quite distinct from *R. puellaris Fr.*, to which Fries, who had never seen Secretan's plant, referred it as a variety *R. purpurina* also has a rosy-sprinkled stem, but is very viscid and more brilliant shining red on the cap.

50. Russula chamaeleontina Fr.

(The color-change Russula.)

Pileus 2-5 cm. broad, *rather small*, fragile, thin, plano-depressed, with a viscid separable pellicle, margin even at first then striatulate, *color varying for different pilei*, mostly some shade of red, purple, etc., fading to yellowish especially on disk. Flesh white, thin. Gills thin, crowded or close, adnexed or almost free, equal, rather broad, sometimes almost narrow, few forked, interspaces venose, *ochraceous or ochraceous-yellow*. Stem 2-5 cm. long, 4-6 mm. thick, white, spongy-stuffed then hollow, *slender*, equal or subequal to subventricose, sometimes subclavate, even or obscurely rivulose. Spores *ochraceous*. Taste mild. Odor none.

Scattered or gregarious. In coniferous or mixed woods. So far only reported from northern Michigan.

Like *R. integra* this has to be considered at present a composite species, from which several species have, from time to time, been segregated. According to von Post, a pupil of Fries, the master himself included many forms which do not fit into his own description; and Romell follows the Swedish tradition and refers to *R. chamaeleontina* all small forms with mild taste and ochraceous gills not otherwise accounted for. "No subacrid forms are included" writes Romell. Specimens with the caps a uniform red, rose colored, purplish, lilac, etc., and accompanied with a yellowish tint, are always included; sometimes also, whitish faded forms must be placed here. Since the limits of the species are not definitely settled in Europe, it seems futile to attempt segregation in this county. There is, however, a subacrid form in Michigan which had better not be included, and I will temporarily refer to it as *var. subacris* (not published). *R. abietina* differs from the above in its habitat under balsam-fir, and the color of the disk being variegated olive-green, etc.

51. Russula abietina Pk.

(The balsam-fir Russula.)

Illustrations: N. Y. State Mus. Rep. 54, 1901. Pl. 7, fig. 1-11.

Pileus 1-2.5 cm. broad, thin, fragile, convex becoming plane or slightly depressed in the centre, covered with a viscid, separable pellicle, tuberculate-striate on the thin margin, *variable in color*, purplish, greenish purple or olive-green with a brown or blackish centre, or sometimes purplish with a greenish centre. Flesh white. Gills narrowed toward the stem, subdistant, equal, rounded behind and nearly free, ventricose, whitish becoming *pale yellow*. Stem 1-2.5 cm. long, equal or tapering upward, stuffed or hollow, white. Spores bright yellowish ochraceous, subglobose, 8-10 mier. Taste mild.

Its place of growth is only *under balsam fir*. It has been reported from Michigan but the description given is that of Peck. The important characters seem to be the bright yellow tinged spores. It is separable from *R. puellaris*, "by the viscid cap, the gills rather widely separated from each other and nearly free, the stem never yellowish nor becoming yellow where wounded, and the spores having an ochraceous hue."

52. Russula pusilla Pk..

(The little Russula.)

Illustrations: N. Y. State Mus. Bull. 122, 1908. Pl. 110, fig. 7-14.

Pileus *less than 3 cm. broad*, rarely larger, very thin, convex then nearly

plane or slightly and umbilicately depressed glabrous even or slightly striate on the margin, the thin pellicle separable, *dark red or crimson*, usually *darker* or brownish *in the centre*, scarcely viscid. Flesh white. Gills broad, subventricose, subdistant or moderately close, adnate or slightly rounded behind, white becoming yellowish-ochraceous or ochraceous-buff with age. Stem 1-2 cm. long, 4-6 mm. thick, relatively stout, solid or spongy within, soft, short, white. Spores globose, *slightly tinged with yellow*, 7.5 micr.

Reported only once from Michigan. They are said to grow on the bare ground or among short grass under pine trees. The coloring matter of the pileus produces red stains on wet paper, or colors water in which they are washed. It is the smallest Russula in this country. July to October. Edible. The description and notes are from Peck's account.

53. Russula flava Rom. (Syn. R. constans. Karst.)

(The light-yellow Russula.)

Pileus 5-8 cm. broad, *rather fragile*, convex, then plano-depressed, *even or slightly striate* in age, dry in dry weather, somewhat viscid when moist, pellicle separable, *dull yellow* (flavus Sacc.), color hardly fading, but sometimes ashy discolored in age. Flesh white *becoming cinereous* with age. Gills white at first, becoming yellowish, broadest towards front, narrowly adnate, close, distinct, becoming slowly gray in age. Stem chalk-white at first, the flesh becoming ashy, equal or subequal, spongy-stuffed, obscurely reticulate-rivulose, rather fragile, 6-8 cm. long, 1-2 cm. thick. Spores *yellowish*, globose, echinulate, 8-9 micr. Taste *mild*. Odor none.

Solitary or scattered. In coniferous or mixed woods of northern Michigan. July, August and September. Frequent.

This mild, dull or pale yellow, rather large Russula, with flesh, gills and stem becoming ashy when old, is quite easily recognized. The name *R. flava* is more appropriate than *R. constans* used by Peck. Romell dropped the latter name, because, according to Britzelmayr who first used the name *R. constans*, his plant is not the same as Karsten's, but Karsten's plant occurs in Sweden, and so had to be renamed. Our plant is the same as the Swedish one, hence the name *R. flava*. It differs from *R. ochroleuca Fr.* in the mild taste and unpolished pileus, etc. *R. ochracea* is described with a shining, sulcate pileus and flesh ochraceous thruout. *R flava* was reported as *R. decolorans Fr. var. constans Kurst.* in the eighth Michigan Academy Report.

54. Russula decolorans. Fr.

(The discolored Russula.)

Pileus 5-10 cm. broad, *often large*, firm, *globose at first* then plano-depressed *orange-red*, usually ochre on disk and dark red on margin, pellicle separable, subviscid, margin even, slightly striate in age. Flesh white *becoming cinereous* with age or where broken, becoming fragile. Gills pale yellowish-ochraceous at maturity, white at first, thin, fragile, moderately broad, close, adnexed, forked at base, few short. Stem *stout*, long, spongy or solid, wrinkled rivulose, white, the flesh becoming cinerous with age or where bruised. Spores subglobose, echinulate, pale ochraceous-yellow, 7-9 micr. Taste mild. Odor none.

Solitary or scattered. In coniferous or mixed woods of northern Michigan. July, August and September. Frequent.

The large size, globose young pileus, orange-red color and the changing flesh easily distinguish it. *R. depallens Fr.* in which the flesh turns ashy, has not with certainty been found. It is said to have whitish gills, and the color of the pileus is dirty red to fawn. *R. decolorans* appears to prefer the regions of the pine and fir, both in this country and in Europe.

55. Russula obscura Romell.

(The ashy-stemmed red Russula.)

Pileus 5-7 cm. broad, rather pliant, convex then plano-depressed, dull, *dark blood-red*, pileus sometimes blackish on disk, thin, the pellicle continuous and separable, hardly viscid when moist, *subpruinose* when dry, even or slightly striate in age. Flesh whitish, becoming ashy. Gills white at first, then dingy straw-color, moderately broad, narrowly adnate, close, mostly forked at base, equal, interspaces sometimes venose. Stem white, *becoming ashy or blackish*, rarely tinged red, subequal, 4-6 cm. long, 10-15 mm. thick, spongy-stuffed, rigid, soon soft, obscurely wrinkled. Spores *pale ochraceous in mass*. Taste mild. Odor none.

Gregarious or scattered, in low woods of southern Michigan. July and Aug. It is found frequently around Stockholm. The examples pointed out by Romell did not seem to possess such a blackish stem as some of ours. This species does not remind me of *R. decolorans*, being a more slender and smaller plant. It might be confused with *R. nigrescentipes, Pk.*, but that species is said to have white spores. *Russula depallens Fr.* seems to be close to it, except that it is said to be a firm plant belonging to the Rigidae group.

56. Russula aurata Fr.

(The golden Russula.)

Pileus 5-8 cm. broad, at first convex-expanded, then more or less depressed in the centre, somewhat viscid or shining, the margin at length striate, daffodil-yellow or orange more or less mixed with purple, scarlet or brown, the yellow usually dominant on the disk, altho the red and yellow may exchange places, with an adnate, thin pellicle. Gills *daffodil-yellow on the edge*, white or pale yellow on the side, broad, shining, equal and free. Stem white, tinged yellow, slightly striate, somewhat shining, cylindrical or slightly thickened at the base, 3-6 cm. long. Spores pale yellow, globose, echinulate, Taste at first mild then slowly and slightly acrid. Flesh spongy, white or whitish, yellow under the pellicle.

Summer and autumn.

This is a very distinct species, not easily forgotten when once seen; its vivid orange-red pileus is as striking among the Russulas, as is that of *Amanita muscaria* among our Amanitas. The edge of the gills is marked by a bright yellow which pervades the whole surface of the plant. It has not been reported in Michigan, but it is to be expected that some one will soon report it. It is a frequent Russula in Sweden *under pines*, and has been found in Pennsylvania and West Virginia by McIlvaine under pines. White reports it from Connecticut, while Peck has apparently not yet seen it in New York.

56. Russula lutea Fr.

(The egg-yellow small Russula.)

Pileus 3-6 cm. broad, *small, thin*, convex then plano-depressed, pellicle easily separable, viscid, margin *even*, becoming slightly striate in age, unicolorus, bright *yellow* or pale golden yellow. Flesh white, very thin, fragile. Gills at length *deep yellow-ochraceous*, *subdistant*, rather broad in front, narrowed behind and free, equal, interspaces often venose. Stem white, unchanged, subequal, stuffed then hollow, soft, fragile, even or obscurely wrinkled, glabrous, 3-5 cm. long, 4-8 mm. thick. Spores globose, echinulate, yellow 8-10 micr. in diam. Taste *mild*. Odor none.

Solitary. Coniferous and mixed woods of northern Michigan. July and August. Infrequent.

Our plant is the same as the one occurring about Stockholm. It agrees with the characters as given in *Hymenomycetes Europaei*, except that the gills are subdistant, not truly narrow but relatively broad in front. The Stockholm specimens had the thin margins of the pileus at length slightly striate, as is also the case with the Michigan plants. Peck says he has found it but once in New York. I have found it a number of times in Michigan. *R. vitellina Fr.* which is said to resemble this species, is not known to Romell for Sweden, who refers all their forms to *R. lutea*. It may be that *R. lutea* and *R. vitellina* represent extremes of the species. Our plant described above, and that about Stockholm do not agree with either of the descriptions, and my description is a compromise between the two. Our plants are not strongly striate nor have they any marked odor like *R. vitellina;* on the other hand they have broader and more distant gills than is warranted by the description of *R. lutea*. According to Fries, *R. lutea* is found in beech forests and *R. vitellina* in coniferous woods. Morgan and McIlvaine report *R. lutea* from beech woods. *R. citrina Gill.* has already been referred to *R. lutea* by Gillet himself, and so falls out of the discussion. *R. flaviceps Pk.* is said to be larger, with narrow and close, pale yellow gills. If we have a number of species of this color in the state, they have not been found in sufficient quantity to settle all the points raised above.

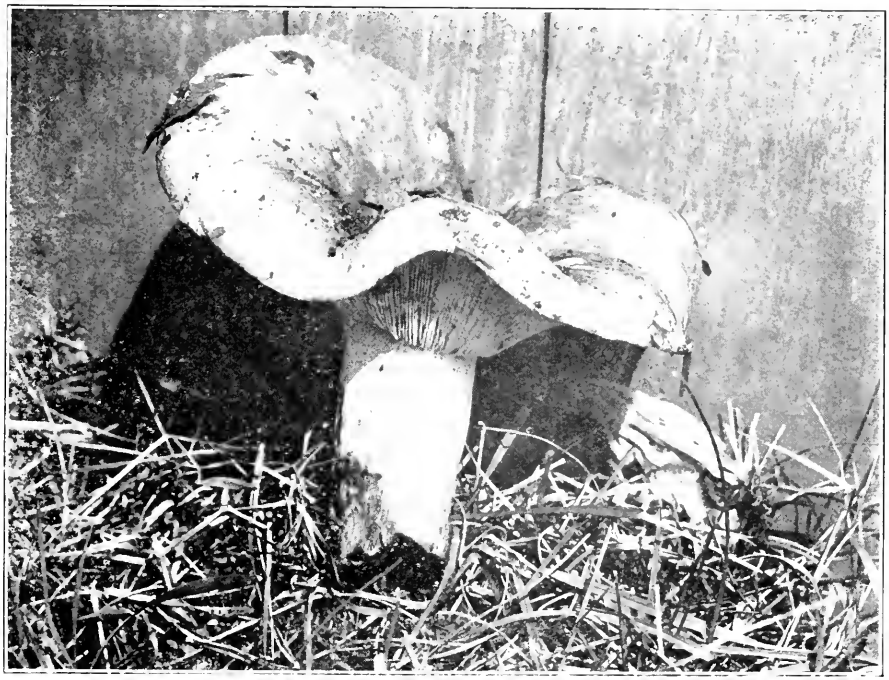


FIG. 1. Russula densifolia Sect. Reduced in size. Photo, O. E. Fischer.

Fig. 2. Russula squalida Pk. Nat. size, often larger. Pileus dull purplish variegated with olive, ochraceus, etc.; gills creamy yellow; stem white. Photo, C. H. K.

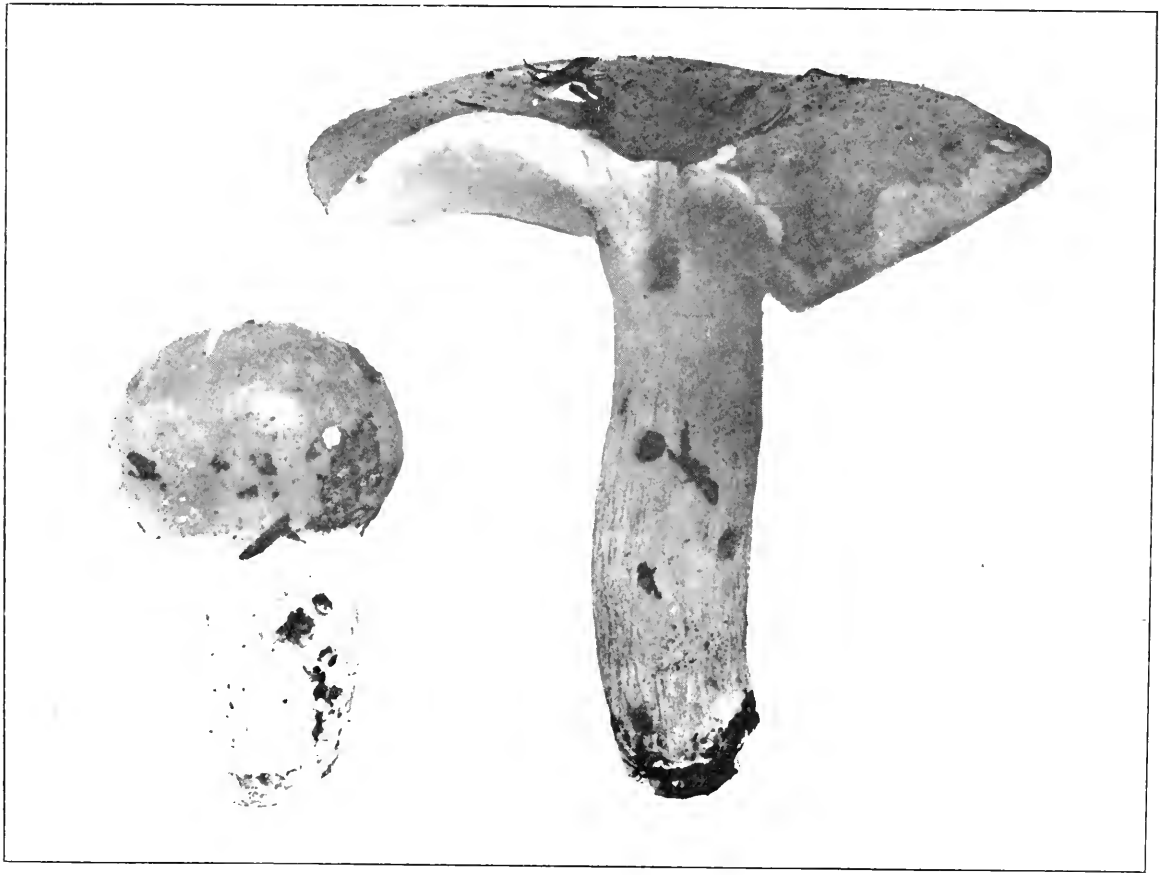


FIG. 3 RUSSULA FLAVA ROM. Nat. size. Pileus dull yellow; stem white; gills becoming yellowish; flesh ashy in age. Photo C. H. K.

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COMPARATIVE GROWTH OF WATER CULTURES IN VARIOUS SOLUTIONS. (ABSTRACT.)

NORMAN W. SCHERER.

The purpose of the experiments was to determine:

1. The most favorable solution.

2. Growth in the solutions. (a) untreated, (b) treated with lampblack, (c) treated with quartz.

3. Relative growth in solutions of one-half, one, two and four liters.

Corn used in all the experiments was gathered by myself on a farm about two miles west of this city. The cobs were taken from one stalk and furthermore, to reduce the variability, the grains in one row were used for one series of experiments. The three standard solutions of Sachs, Crone, and Knop were used.

The result of the above set of experiments was as follows:

1. It is difficult to say which was the most favorable solution, but in my estimation the plants growing in Knop's solution were the best.

2. Assuming the growth in untreated solutions as standard and comparing the other treatments with it, those solutions treated with lampblack gave a retarding effect as did those treated with quartz.

3. It was found that growth increased with the quantity of solution used, the concentration remaining the same.

To verify these results experiments were made with large numbers (134) of cultures. The results were strikingly similar but more marked. In the cultures to determine the best solution, Knop's solution was easily the first with Sachs' solution second and Crone's solution third. The plants in Knop's solution were about five and a half feet tall having tassels and ears with silks; some were cross pollinated by hand and yielded a number of grains of corn.

The solutions treated with lampblack gave very striking results. The roots did not get over three inches long and were very much bunched. The tips of the roots were coated with a black slime. It was thought that the result was due to impurities of sulphur or creosote in the lampblack, so I made some lampblack with a Bunsen burner and a revolving flask. The result of the experiments in this case was more marked than before. The seedlings died before they were eight inches high.

The quartz used was supposed to be pure, but on examination was found to contain many impurities. Through the courtesy of the Wausau Quartz Company, Wausau, Wisconsin, I give the following analysis according to the State Geologist as follows.

Silica	99.07%
Iron oxide	0.17%
Alumins	0.52%
Hygroscopic water	0.66%
Undetermined	0.18%
	100.00%

The roots of the plants gave streaks of iron along the sides of the jars showing the impure iron present.

Transpiration amounted to one quart of solution per liter per week. Solutions were replenished from a stock solution.

Growth was measured directly with the metric scale, the tables of measurements cannot be tabulated on account of lack of space.

The color of the plants was very good in the case of the solutions treated with the quartz. The leaves were a dark velvety green, tinged with red and the plants looked natural as though grown in the open. It was found that the plants became yellow colored and that the green color could be restored by aeration and addition of ferric chloride solution in the proportion of one cubic centimeter of .5/N ferric chloride solution to one liter of water. Addition of ferric chloride alone or aeration alone would not restore the green color.

There was a question as to the change in the concentration in the solutions, so transpiration was allowed to continue and white crystals of minerals, undetermined as yet, were deposited on the roots above the liquid, showing concentration in some form. The specific gravity of each solution was tested with a hydrometer and they were all found to be 1,000, showing change in concentration so slight as not to be detected by the hydrometer. Transpiration in Knop's solution was just about twice as fast as in the other solutions. This might be explained by the molecular weight formula of the solutions as follows:

Sachs.	*Crone*	*Knop.*
$MgSO_4$ .58.	Pot. nit. 1g.	$MgSO_4$ .25g.
NaCl .5g.	Ferrous Phos. 1g.	Ca Nit. 1g.
Pot. Nit. 1g.	CaSO .5g.	Acid Pot. Phos. .25g.
$CaSO_4$ .5g.	$MgCO_3$ .5g.	KCl .12g.
Ca. Phos. .5g.		
3g.	3g.	1.62 g.

Transpiration might be said to be inversely proportional to the concentration (molecular weights) of the solution.

A series of cultures were made each having one compound in one solution, and one jar with only distilled water. Cultures in all cases were sterilized at a temperature of 112_0 C. and a pressure of 12 pounds. Plants were put in each jar and changed every day, thus exposing the roots to a different compound each day. A sort of slime was noticed about the root tips of the plants in solutions containing minerals but not in those solutions having just distilled water. In the case of the jar with the ferric chloride, the dilution color was so great as to be invisible by the naked eye, but the slime of the roots concentrated the ferric chloride mineral so much as to give a dark brown color. Whether this slime is an indication of minerals going into the colloidal condition to be absorbed and used directly by the roots is an undecided question and needs a further study and investigation.

Fungi and bacteria are great sources of trouble in water culture experiments, probably due to improper methods of sterilization. Cultures must be watched as regards the amount of solution present, color of plants, and foreign matters, fungi, etc. In my experiments, I had one case of an iron reducing bacterium which threw down the ferric chloride out of solution as a cinnamon red precipitate. Care should be exercised in the weighing out and mixing of minerals. It was found that minerals mixed in different ways give insoluble precipitates.

Brief of a paper given before the Michigan State Academy of Science, 1909 and the original manuscript with the Botanical Department of the University of Michigan.

University of Michigan, Ann Arbor, Mich., May 1, 1909.

THE OCCURRENCE AND ORIGIN OF THE BROWN IRON ORES OF SPRING VALLEY, WISCONSIN.

R. C. Allen.

Iron ores were discovered in the vicinity of Spring Valley in Pierce county, Wisconsin, about twenty years ago. Thorough prospecting developed a number of deposits, two of which, known as the Gilman and the Cady deposits, are being mined. The Gilman was opened about 1890 and has been in operation more or less continuously since that time. In 1893, a furnace was erected at Spring Valley for smelting the Gilman ores and charcoal ovens were built in the vicinity to supply fuel for the furnace, but later, charcoal was supplanted by coke as a fuel and the ovens went out of use. The original plant has been partly replaced by a more modern one. The furnace is 63 feet high by 7½ feet hearth and 13 feet bosh. There are two blowing engines with a capacity of 14,000 cubic feet of air per minute, three fire brick stoves 63 feet high by 17 feet drain with a chimney 150 feet high by 7 feet drain, three batteries of two Cornish boilers each and a Mehan upright water tube boiler* A considerable part of the ore which is used in the furnace in obtained from the Mesabi and Penokee ranges, the remainder being mined from the Gilman and Cady deposits near Spring Valley. The furnace product is a non-Bessemer foundry iron varying from a thin low silicon iron to a thick high silicon iron. The slag is sold to the railroad for ballast, for which it is excellent. Limestone for flux is obtained from a quarry seven miles nearly south of Spring Valley and brought to the furnace by rail. The rock is a dolomite and contains, by analysis of a year's average sample, dried at 212 degrees F:

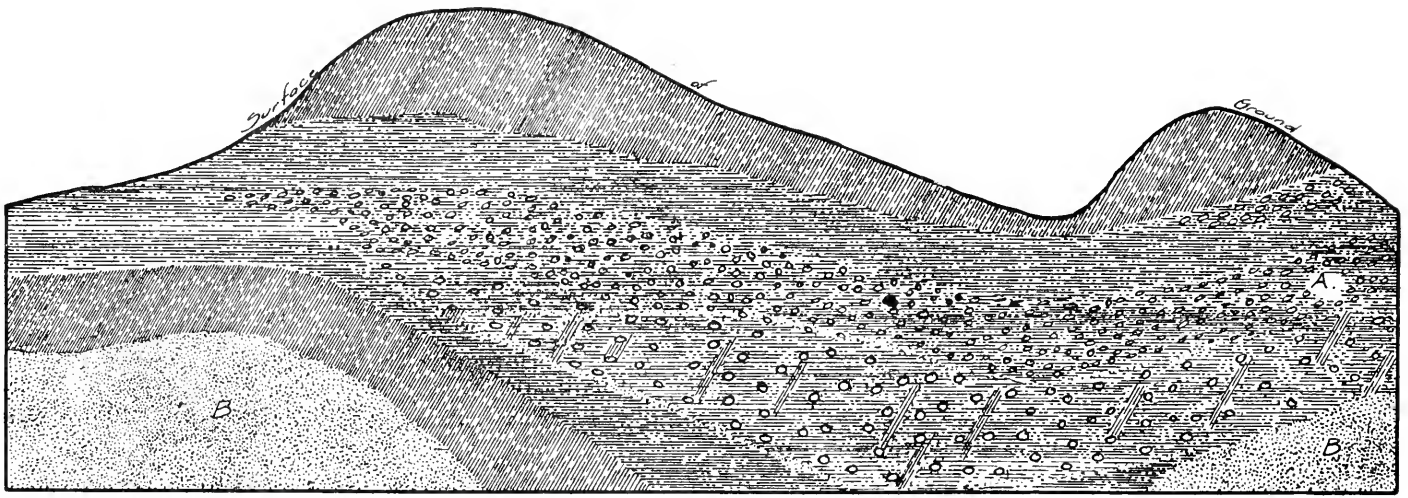
Fe	SiO_2	P	Mn	Al_2O_3	CaO	MgO	FeO
1.05	5.00	.015	.06	2.15	31.5	20.56	1.51

The furnace, mines, and quarry are owned and operated by the Spring Valley iron and ore company, Frederick H. Foote, President and Treasurer.

The Gilman Deposit.

The Gilman deposit rests on an eroded, irregular surface of the Magnesian limestone, near its base, on the very upper slopes of a ridge above the valley of a small creek tributary to the Eau Galle river. It is on the C., St. P., M., & O. Ry. railroad and is west of Spring Valley 1½ miles. The deposit is very irregular in outline, as shown by the mine workings, which are open shallow excavations, the deepest being not more than 30 feet. The ore is mainly a brown, hydrated hematite and occurs as nodules and concretions mixed irregularly with ocherous clay, sand, and chert fragments and nodular concretions of sand and clay. Locally, the deposit shows very rough and irregular bedding but its general absence is conspicuous. (Figure 1.) The limestone presents an uneven surface to the bottom and sides of the deposit. In one place a wall of limestone some 6 feet or 8 feet high, showing undoubted evidence of having been eroded while exposed to the air,

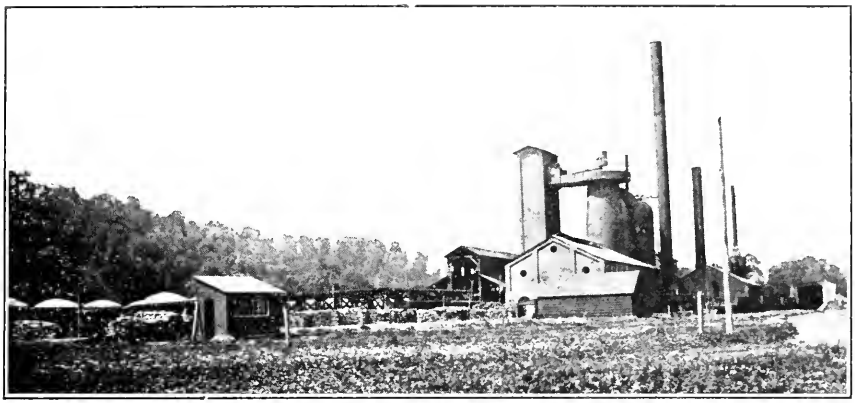
*The writer is indebted to Mr. W. H. Foote, of Spring valley, for photographs, details of plant and analyses here given. Mr. George Fitzwilliams of Ely, Minnesota, kindly furnished the analyses of the Cady ores.



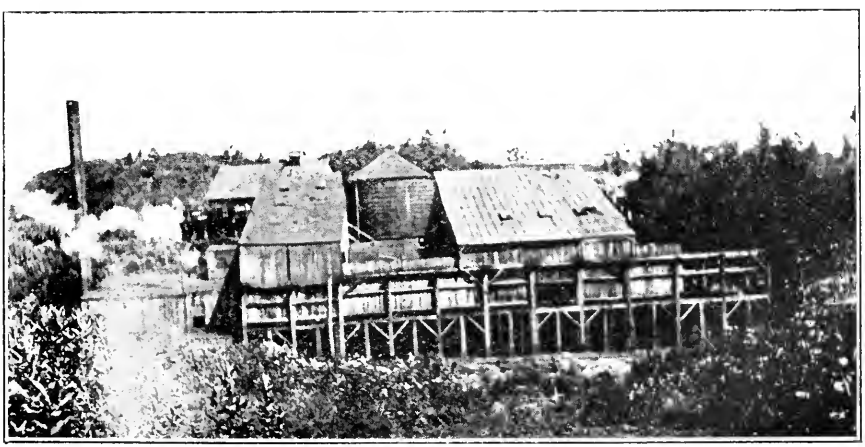
Section Exposed in Workings of Gilman Mine.

Legend: Clay = ; Chert & Sand = Nodules of Limonite & Hematite =
Sandstone . Horizontal and Vertical Scale 1" = 3'.

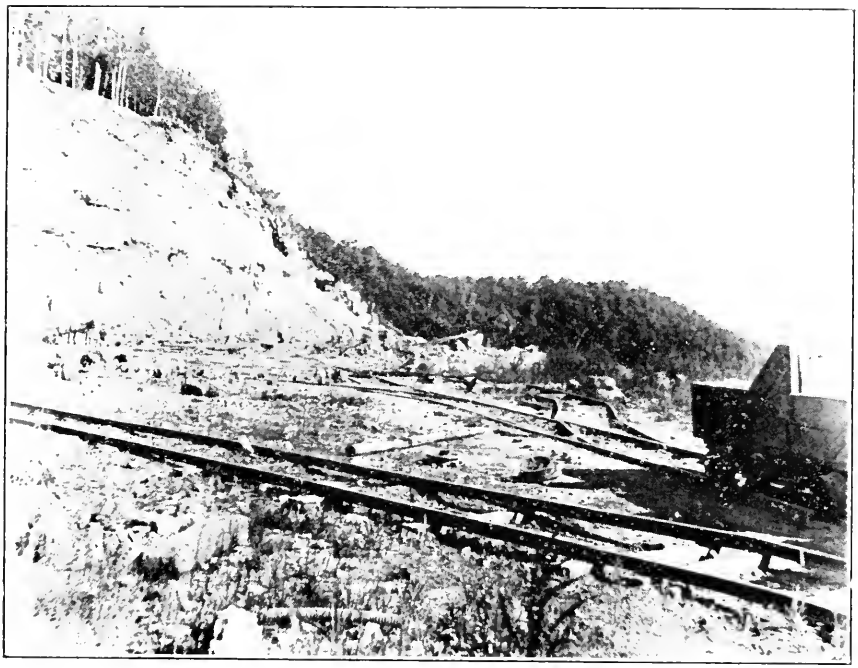
FIG. 1.



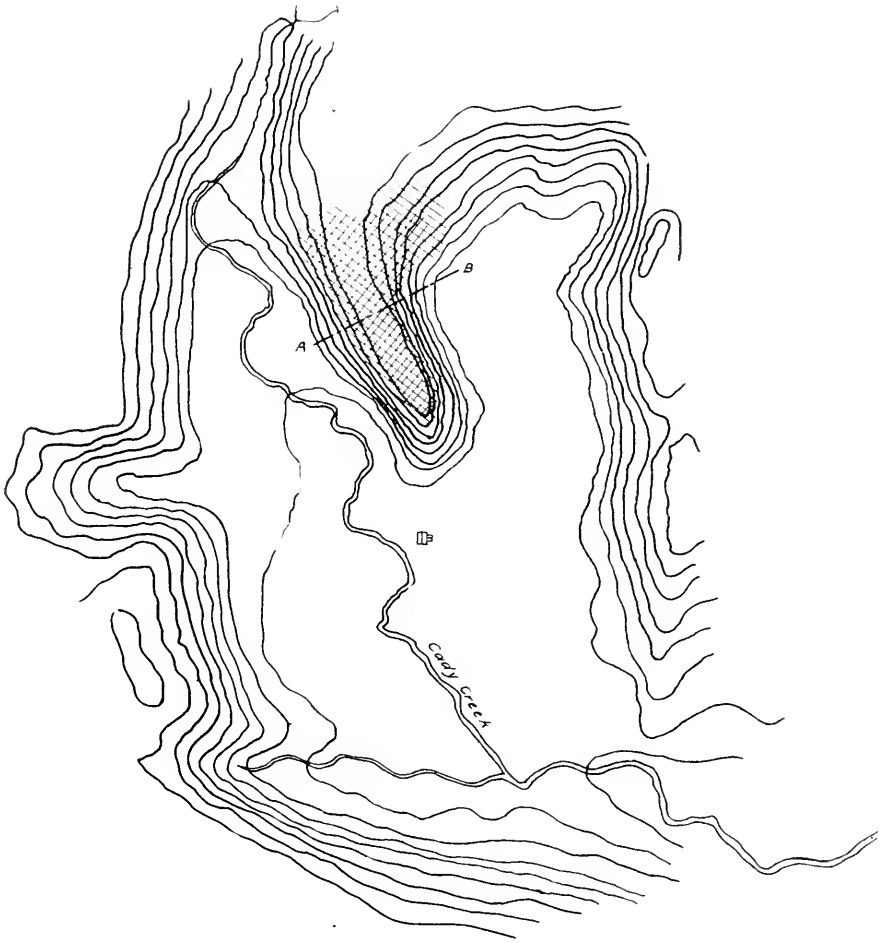
The Furnace at Spring Valley, Wis.



Power House and Washery. Gilman Mine.



Lime Rock Quarry. Spring Valley Iron and Ore Co.



Field Sketch Showing Topography in Vicinity of Cady Iron Deposit

Fig. 2.

abuts directly against the ore. Sometimes the ore comes quite to the surface but it is usually covered by from one to several feet of clay. All of the mining is done by hand. The larger nodules called "rock" ore, some of which need to be broken up by blasting, are picked by hand from the clay and sand in which they are embedded but the greater part of the ore is mined with the impurities in which it occurs and separated by washing in barrel washers. The following is the analysis of a three month's average sample of "rock" and "wash" ore:

Fe	SiO_2	Al_2O_3	CaO	MgO	P	S	Mn
43.6	24.00	2.3	.58	.30	.14	.018	.80

The Cady Deposit.

The Cady deposit is 2½ miles northwest of Elmwood and southeast of Spring Valley about 5 miles. It covers several acres on the top and upper slopes of a high ridge that rises steeply above the valley of Cady Creek. (Fig. 2.) As in the Gilman deposit the ore rests on the Magnesian limestone. At the time of the writer's visit the deposit had not been opened but the ore was exposed in numerous pits and trenches. According to Mr. W. H. Foote, at one point a shaft was sunk through 80 feet of ore and struck a face of limestone at that depth which was at an angle of 60 degrees with the horizontal. Ore was followed down this face for 40 feet more with no bottom. The following analyses indicate the character of the ore in this shaft.

Analyses of Cady Creek Ore.

	Depth	Fe	SiO_2	Mn	$Phos_i$
Blue lump ore.....	10′	59.12	9	2.03	.075
Brown lump ore.....	10′	49.96	14.33	.83	.073
Brown hematite.....	16′	47.79	20.5	1.39	.078
" "	22′	32.96	45.25	2.13	.076
" "	28′	46.56	22.17	2.47	.077
" "	34′	52.02	11.82	2.51	.054
" "	40′	37.91	35.34	1.82	.068
" "	45′	55.11	.....	1.73	.062
" "	50′	53.56	.....	2.72	.062
" "	55′	52.02	.....	2.25	.062
" "	60′	52.22	.....	1.91	.068
" "	65′	54.18	.....	1.33	.060

The Cady ore contains a somewhat higher per cent of iron, has a greater proportion of "rock" ore, and is associated with a lesser amount of impurities i. e., sand, clay, etc., but is otherwise exactly similar to the Gilman ore.

Geology and Topography.

The Potsdam sandstone, of Upper Cambrian age, underlies the valleys and the lower hill slopes. The uplands are formed by the Magnesian limestone of Ordovician age. The strata are conformable and nearly flat lying. The position of the area with reference to the axis of the broad central and southern Wisconsin anticline indicates an average slight dip of the strata toward the southwest.

The topography is that of the maturely dissected plateau, which is characteristic of the larger part of the driftless area of the Upper Mississippi

Valley, and is essentially of pre-glacial origin. The area in the vicinity of Spring Valley lies within the margin of the Illinoian drift sheet which trends southward through the western parts of Dunn and Pierce counties a few miles to the east.* However, the drift is here so thin that it does not modify to any great extent the pre-glacial features of the topography. The Eau Galle river, which flows southeastward to the Chippewa, and its tributary creeks are flowing in rather steep sided valleys deeply incised below the uplands. Were the present valleys filled to the average height of the uplands the resulting surface would be a plain. Such a plain probably existed here, in the past, as part of a greater one which extended over a surrounding broad area and was probably continuous with the southern Wisconsin peneplain, remnants of which are still preserved in the crests of ridges and uplands which rise to an approximately even plane horizon. Above the horizon marked by the inter stream uplands of southwestern Wisconsin, rise the monadnocks represented by the Blue, Platte, and Sinsiniwa Mounds, and below it are the valleys in some of which rivers are still flowing in the meandering courses developed on the ancient peneplain.†

The erosional history of the driftless area of the Upper Mississippi Valley is recorded in the features of the present topography, which is also an index to the pre-glacial erosional history of an area of much broader but undeterminable extent, including the vicinity of Spring Valley, now covered in part by deposits of glacial drift completely surrounding the driftless area.‡ As the formation of the ore deposits described above was an incident in the physiographic development of this region, the physical history will be briefly summarized.

A glance at the geological map of Wisconsin shows a concentric banded surface distribution of the successive rock strata around the southern edge of the northern Wisconsin highland of Pre-Cambrian rocks. This distribution is due in part perhaps to each of three factors: (1) the highland of northern Wisconsin may have existed as a land mass in the sea in which the various Paleozoic sediments were deposited; (2) these sediments were later involved in earth movements which produced a low broad anticline pitching gently southward with axis trending in a general north-south direction through the central part of Wisconsin. (3) Erosion has been operative since the appearance of the rocks above the sea. The crest of the fold has been more deeply denuded than the limbs because of its relatively higher altitude, which is seen by a glance at the lines of drainage, and the surface distribution of the rocks is practically that which would be produced theoretically by the descent of a plane horizontal erosional surface on the low gently southward pitching anticline. It is not possible to estimate the relative values of these three factors in bringing about the present surface distribution of the successive rock strata. Indeed, it is not certainly known that the northern Wisconsin highland formed a land area in the Paleozoic sea. The occurrence of Cambrian strata on the south shore of Lake Superior indicates a possible former connection across the intervening highland with the Cambrian sandstone of central Wisconsin. The highland may have been covered with rocks of still younger age.§ This possibility is apparently ignored by Davis

*Chamberlain, T. C., and Salisbury, R. D. The Driftless Area of the Upper Mississippi Valley. United States Geological Survey, Sixth Annual Report. See map opp. page 259.

†Kummel, Henry B., Some Meandering Rivers of Wisconsin. Science, New Series Vol. 1, pp. 714-16. 1895.

‡Chamberlain, T. C., and Salisbury, R. D. The Driftless Area of the upper Mississippi Valley. United States Geological Survey, Sixth Annual Report, pp. 206-322.

§Weidman, Samuel. Geology of North Central Wisconsin, Bulletin 16. Wisconsin Geological and Natural History Survey, pp. 600-601, 1907.

who hypothecates the existence of "oldland" in northern Wisconsin and explains the belted distribution of the Paleozoic strata as due mainly to the southward migration of the Paleozoic shoreline thus leaving out of consideration the effect of erosion on the distinctly anticlinal structure of the rocks.*

Broadly considered, the topography of the driftless area may be interpreted as the result of an uplift by which the streams were rejuvenated and were thus enabled to sink their channels rapidly below the uplifted surface. That the uplifted surface was degradational in origin is certain but there is some difference of opinion regarding its physiography. In southwestern Wisconsin it was a peneplain as is indicated by evidence already cited. The physiographic history for that part of the area as summarized by Kümmel† and concurred in by Grant‡ is: (1) Country almost completely baseleveled. (2) A few monadnocks left on the surface of the peneplain. (3) The region uplifted and the rivers rejuvenated. (4) The rivers have again cut down almost to their grade. The areal extent of this peneplain has not been determined. It has been suggested that it was local and developed on the surface of the Galena limestone because of the hardness of this formation. However, the Galena limestone is not peculiarly resistant to erosion and could not sustain an erosional surface far above the level of the Mississippi which determined the base level of erosion for the whole of the region comprised within the limits of the driftless area.

The description of the topography of southwestern Wisconsin also applies to adjacent portions of Illinois and Iowa and, in a general way, to a very large part of the driftless area to the north including the vicinity of Spring Valley. While it cannot be proven that the ancient surface, the horizon of which is marked by the uplands of the driftless area, was a peneplain throughout its entire extent, it is probable that the topographic cycle had approached the stage of old age and in southwestern Wisconsin had neared completion prior to the second pre-Pleistocene marked uplift. Irregularities of surface, which in the earlier stages of the cycle were accentuated by the varying hardnesses of the exposed rocks, had been greatly reduced and the degradational plain beveled more or less indiscriminately, at a low angle, the edges of the gently southwestward dipping strata.

Origin of the Ores.

Turning now to the Spring Valley area, we may conceive that prior to the uplift the streams were near grade and their valleys were wide and shallow. The surface of the land approached a plain and was covered with residuum from long ages of rock decay. The water table was near the surface and consequently the belt of weathering was thin, thinner than at any time earlier in the topographic cycle. The underground circulation was sluggish because of the loss of head resulting from the flattening of the surface and lowering of the general level of the land. Because of the low relief and the consequent nearness of the water table to the surface, a relatively large part of the precipitation reached the belt of saturation in which it seeped slowly toward the stream channels where it finally joined the overground run off.

It is well known that in the process of rock weathering ferrous iron is oxidized to ferric oxide which is practically stable under weathering

*Davis, William Morris. Physical Geography, Ginn and Co., 1899. p. 137.
†Kummel, Henry B. Some Meandering Rivers of Wisconsin. Science, New Series, Vol. 1, pp. 714-16, 1895.
‡Grant, U. S. Lead and Zinc Deposits of Wisconsin, Bulletin 14, Wisconsin Geological and Natural History Survey, p. 11.

conditions. This accounts for the accumulation of ferric oxide, so frequently noted, in the residuum produced by rock decay. However, if abundant organic matter is present in the soil layer on the weathered mantle, conditions are favorable for the reduction of the ferric oxide to ferrous oxide, and the formation of carbon dioxide. The presence of decaying organic matter in the soil thus not only reduces the ferric oxide but furnishes at the same time, in the presence of water, a solvent for the ferrous oxide which may be taken into solution and carried downward to join the underground water circulation or to be reprecipitated as ferric oxide before reaching the belt of saturation. If the belt of saturation be near the surface a proportionately large amount of the ferrous iron will join the underground waters, in which it may be transported to places where the conditions are favorable for oxidation and precipitation. Under the physiographic conditions outlined above, such places would be found along the overground drainage lines where the underground seepage waters mingled with the oxygenated surface waters. If the surface waters were sluggish or ponded in marshes the precipitated ferric oxide would sink and become mingled with the mud and sand of the bottom.

Some such conditions are believed to have prevailed in the vicinity of Spring Valley when the Gilman, Cady, and other smaller but similar deposits were formed. The accumulation of the ores in favorable places along the stream courses was terminated by an uplift of the land and the resumption of downward cutting by the streams. The valleys were rapidly deepened and the water table was correspondingly lowered in relation to the land surface, while at the same time the underground circulation was invigorated. Where ore deposits had formed in the old valley bottoms they were cut through and partially removed. The Gilman, Cady, and other deposits, were formerly of much greater extent, just how much greater can not be determined, but their present positions on the upper slopes of the valley sides would seem to indicate that the parts which have been removed are greater than those that remain. The topographic relations shown in the Gilman and Cady deposits are common to all of the other smaller deposits in the Spring Valley area. Says Mr. Wallace Foote, "most of the ore in this country is on the sides of hills or on the very edge of the top." Those deposits which were formed nearest the divides in the old valleys would be now at greater elevations than those formed further down stream had none of the deposits been moved from the positions in which they originated, and deposits formed in different valleys would probably be at somewhat different elevations, but the chief cause for the varying altitudes of the deposits is probably to be found in the tendency of the ore beds to creep downward over the steep valley sides toward the stream channels. This is well illustrated in the Gilman deposit where the ore has slumped downward at least an amount sufficient to completely bury a rock cliff which was formerly exposed to the air and formed part of the valley side. In this downhill creep the ore has become intermixed with residuum as is shown by the presence in the ore bed of numerous more or less decomposed chert fragments derived from the decay of the underlying limestone in which chert is abundant. The remarkable thickness of the ore in the shaft at the Cady mine and its relation to the face of limestone which was encountered at a depth of 80 feet and followed downward at an angle of 60 degrees for 40 feet is accounted for in the same manner. The ore has slumped downward over the hill side and completely buried a limestine cliff. The history of a deposit of this character is indicated in figures 3 and 4.

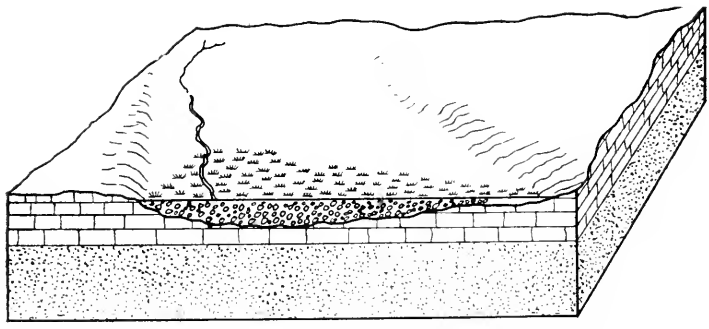


FIG. 3.—Illustrating the formation of a deposit of bog iron ore.

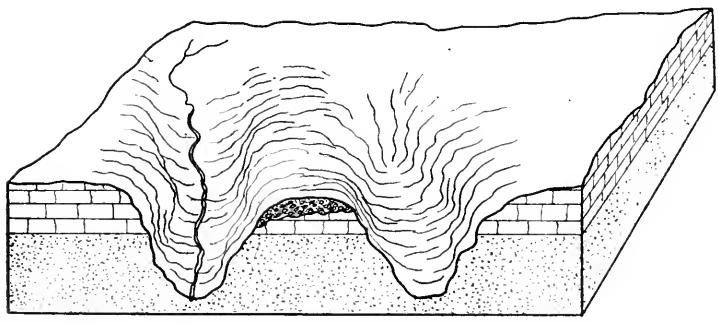


FIG. 4—Illustrating the effect of an uplift of the land. The valleys are deepened and much of the ore bed shown in Fig. 3 has been eroded away and that part which remains is now on a hill.

OTHER SIMILAR DEPOSITS IN WISCONSIN AND IOWA.

Ores of the type represented by the Gilman and Cady deposits, have been reported from other points in the driftless area of Wisconsin north of the Wisconsin river. The known deposits are of no commercial importance but it is worthy of note that these occurrences bear the same physiographic relations to valley slopes and upland surfaces as do the Gilman and Cady deposits. Similar physiographic relations are shown by deposits of similar character in Allamakee county in the northeastern part of Iowa. The largest of these lies directly above the valley of Village Creek near Waukon. It forms a mantle of inconsiderable thickness on the top and upper slopes of Iron hill, the highest hill in the county. The other deposits are in similar topographic relations but are at different and somewhat lower elevations. According to Calvin,* "at all points mentioned the ore is a comparatively thin veneer lying over the hill top. As already noted the beds of ore that have attracted attention all lie on high points, the highest in the entire county. They are all underlain by from 50 to 100 feet of Trenton limestone, with the

*Iowa Geological Survey, Vol., 4, 1895, p. 98 et seq.

exception that, on the south side of Iron Hill, the ore comes down so as to partly overlap the St. Peter sandstone." The origin of these deposits is explained by Calvin as follows: "Ever since the process of rock decay began over Allamakee county the geest has been highly ferruginous and capable of serving as a source of supply to agents concerned in the accumulation of iron ore. During the greater part of the time since the Carboniferous period the surface of the country has been covered with a rank growth of vegetation, mostly aboreal, which, falling and decaying in countless successive generations, furnished a second essential for ore concentration. An imperfectly drained area, or marsh of sufficient extent, constant as to position for a considerable period of time, and receiving the ground water from many square miles of adjacent territory, that rises in very gentle slopes, is the only requisite condition remaining."

Thus, the deposits in Allamakee county, Iowa, originated, according to Calvin, under physiographic conditions which were identical with those which are believed to have prevailed in the vicinity of Spring Valley when the Gilman and Cady deposits were formed. In both areas the ores were formed prior to an uplift which probably affected both areas at the same time and which terminated the formation of ores in both areas. *In other words, the deposits of Allamakee county, Iowa, and those of Pierce county, Wisconsin, are probably contemporaneous or nearly so and are to be connected with a period of planation, or possibly peneplanation, which affected the entire region, prior to the uplift, within the limits of the driftless area and an indefinite extent of country surrounding it.*

Ann Arbor, April 1, 1909.

STANDARDIZATION OF CONTACT INSECTICIDES.

E. M. Houghton H. C. Hamilton.

(From the Research Laboratory of Parke, Davis & Co.)

At first thought there may not seem to be a very close connection between the subject of this paper and the section before which it is read; but, since Sanitary Science concerns itself with anything which affects the health of the community, what is more interesting and vital than the agencies which tend to cause and to spread disease?

Outbreaks of infectious and contagious diseases have therefore, been most carefully studied to learn the life history of the organism concerned. As a result of these studies, it was discovered that in spreading disease insects play a most important role. The direct or indirect connection of flies with the spread of typhoid fever, mosquitoes with malaria and yellow fever, fleas on rats with bubonic plague, southern cattle ticks with the splenetic or Texas fever of cattle, and a number of other cases just as interesting have been proven beyond a doubt. The necessity for an accurate means of standardizing insecticides is, therefore, clearly apparent.

"Contact Insecticides" is a term used to denote such preparations as are more or less effective when applied externally to insects, but which are relatively non-toxic. Their non-toxicity is evidenced by the fact that, when applied to the leaves of plants or to the skin of animals, insects are not injured by feeding thereon, as is the case when arsenic is used.

The particular insecticides to be considered are those of which creosote oil is the effective ingredient and which are permitted by the Department of Agriculture for use in curing sheep scab. Of necessity, when the U. S. Government assumes the responsibility of approving the use of a product which is to be purchased, certain restrictions must be placed on its manufacture to insure the use of proper material and uniformity in composition. This is what is meant by "Standardization."

Standardization in general is accomplished in a variety of ways; for example, lime and sulphur solution should be adjusted to a definite standard by determining the amount of sulphur as soluble sulphide and directing such a dilution as will contain a definite quantity in this form. Arsenic compounds should be assayed to determine not only the arsenic present, but the form in which it appears, since the soluble form is injurious to the host, both to animals and plants.

Certain very valuable medicinal substances are of such a nature that their efficiency can be determined only by a pharmacological assay; that is, to determine how much must be administered to an animal to neutralize some antagonistic substance or to produce a certain definite effect. In the latter case, comparison is made with the standard, which is a similar preparation from the same drug and known to be of average activity. Such a method of assay as that last described is applied for one to the other of three reasons:

The constituents to which the drug owes its value may not have been isolated;

The constituents may be well known, but of such a nature as to make a quantitative chemical assay difficult even if possible;

The constituents may be of such a complex character that the presence or absence of one of them might pass unnoticed or be disregarded in a chemical assay.

When any substance is standardized by pharmacological assay, no definite percentage of active constituents is claimed, but only that its activity has been determined by actual test on animal, insect or germ to be fully equal to standard, and, therefore, that under ordinary conditions a certain amount or a certain dilution will be found efficient.

Standardization by chemical test, however, can be more specific, and the specifications to the manufacturers of creosote oil dips is given in definite quantities of oil and cresylic acid, which must appear in an approved dilution.

The following specifications have been promulgated by the Bureau of Animal Industry, of the U. S. Department of Agriculture:

"And pending further investigation the following dips may be used for the eradication of sheep scab:

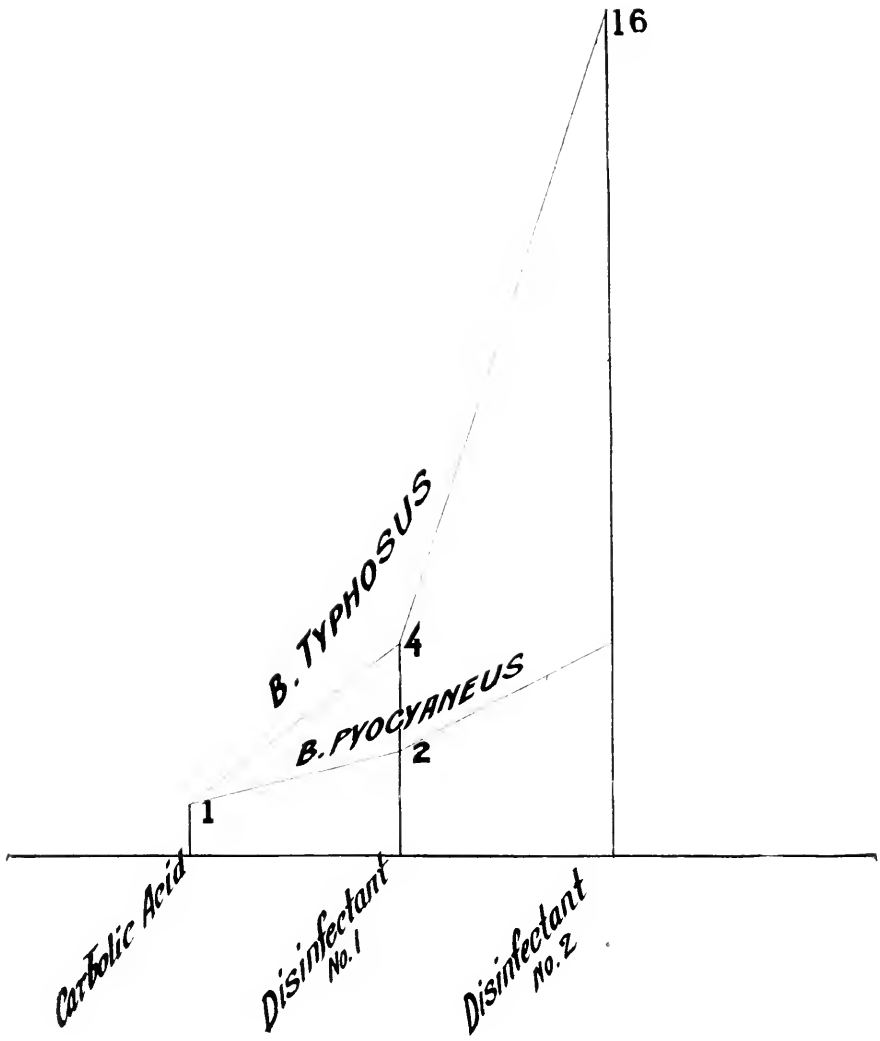
(a) Cresol dip, which consists of a mixture of cresylic acid with soap. When diluted ready for use, this dip should contain ½ of 1% of cresylic acid.

(b) Coal-tar creosote dip. This dip when diluted for use should contain not less than 1% by weight of coal-tar oils and cresylic acid, nor less than 1-10 of 1% of cresylic acid; but when the proportion of cresylic acid falls below 2-10 of 1%, the coal-tar oils should be increased sufficiently to bring the total of the tar oils and cresylic acid in the dilution up to 1.2% by weight. Reg. 33. B. A. I. Order No. 143.

Saturating the interior surfaces of cars, etc. with 5% solution of carbolic acid or a solution containing 2% of cresol,—where this is used it must be mixed with soft soap to make it more easily soluble in water." Reg. 45. B. A. I. Order No. 143.

The extracts quoted are the specifications the Bureau of Animal Industry considers sufficient to secure the best coal-tar insecticide for the treatment of sheep scab. With no knowledge of how such a preparation affects the insect, whether as a poison or mechanically, and with, evidently, no knowledge of what constituents of the oil—the acid, neutral or basic—are of value, a chemical basis of standardization is adopted and measures taken to enforce these requirements in special cases. There is, apparently, the idea that germicidal and insecticidal values are dependent upon the same constituents, since tar acids or cresylic acid are required in solutions for both purposes. The fact that the relative values of gemicidal preparations may be roughly determined by chemical test is frankly admitted to be the reason for adopting a similar method of assay for insecticides. There is a radical difference, however, between the two cases, as the value of coal tar disinfectants is known to reside almost entirely in the tar acids, the quantity and characteristics of which may be easily determined by chemical assay.

But, even for the standardization of coal tar germicides, a chemical assay is of only limited value, as the tar acids from some oils seem to have a selective action on certain bacteria, destroying them in high dilutions, while others of different origin, but having almost the same physical and chemical properties, require much stronger solutions to produce the same results. Two samples of cresylic acid, 98% pure, having boiling points ranging from 200° to 250° C. with practically the same amount distilling between any two degrees, have been found to have the values 1, 4 and 16, using carbolic acid as the unit and B. Typhosus as the test organism, while with B. Pyocyaneus as the test organism the relative values are 1, 2 and 4, which is graphically shown in the accompanying chart.



With such an evidence of the uncertainties and limitations of a chemical examination of coal tar disinfectants, of which the active constituents are known, what value can there be in such an analysis for insecticides when so little is known of the constituents which give them value or the exact nature of their action? Section (c), Regulation 33, of the specifications quoted requires the presence of ½ of 1% of cresylic acid in the diluted dip, while section (d) requires 2-10 of 1% if, at the same time there is present 8–10 of 1% of the hydrocarbons of creosote oil other than Cresylic acid. This implies that 8-10 of 1% of these neutral hydrocarbons is equivalent to 3-10 of 1% of cresylic acid, which is making very fine distinctions when it would be impossible for the point to be proven in practical work.

Very elaborate methods have been published in Bulletin No. 107, B. A. I.,

by which the various ingredients of such dips may be determined with exactness, no detail having, apparently, escaped the analyst. Such exactness is, of course, commendable where any good can result, but when there appears not to have been any test made to determine whether a difference of 10% in the quantity of the supposedly active ingredients can be detected in the efficiency of the dip and when, as an actual fact, such a difference is almost impossible of detection, the absurdity of such extreme exactness is apparent.

Cresol Dip:
Linseed Oil Soap U. S. P.
Cresylic Acid B. P. 185° to 210°.

Cresote Oil Dip:

Cresote Oil	77	with 20% Cresylic Acid.
Rosin	17	
Caustic Soda	1	
Water	4	
Sulphur	1	

ANALYSIS OF CREOSOTE OIL DIPS INCLUDES DETERMINATION OF:

Water.
Soda and Pyridine Bases.
Phenols.
Neutral rosin substances.
Light oils.
Naphthalene and solid hydrocarbons.
Creosote oil.
(Bull. 107 Bureau of Animal Industry).

Another reason why such elaborate methods are of little value is that the standardization of a dip is made on the basis of two ingredients only, namely, the hydrocarbons and the phenols or tar acids, the dilutions allowed being based on these factors alone, the other ingredients—resin, alkali and water—being of value only to bring about proper physical conditions, while a physical test is made to determine whether the proper quality of emulsion can be made.

Recognizing the necessity for some means of standardizing insecticides and, especially, those composed of material like creosote oil, a method was evolved which, although inaccurate when compared with chemical exactness, is actually a means of maintaining a certain degree of uniformity in such products; but, what was of far greater value, it lead to the discovery that it is possible to prepare a creosote oil dip having an efficiency many times greater than that of the average of such preparations. This was brought about by a judicious mixture of biological and chemical methods, to which the name "Biochemic" might be applied, to borrow the word used by the Bureau of Animal Industry. This method was first published in a paper which appeared in the 10th Report of the Michigan Academy of Science, and to this we can refer you for additional data. In brief, it is as follows:

Some insect of which a more or less constant supply is available should be selected as the test organism. The apparatus needed is of the simplest kind, consisting only of a cylinder with graduations of 1 cc. to 100 cc. for making dilutions, some 2-inch glass tubes, open at both ends with a diameter of about one-half inch, in which to place the insects, with porous

cloth to cover the open ends and so imprison them, a hook to suspend and agitate the tube in the diluted insecticide, a time piece recording seconds and, finally, clockglasses or petri dishes to confine the insects, if not killed, and to allow frequent examinations. Some commonly used dip should be taken as standard, preferably one which has given good results in some certain dilution. Then, various dilutions, such as 1 in 200, 1 in 100, 1 in 50, 1 in 30, should be tried by dipping insects enclosed in the glass tubes into the dilutions mentioned, for exactly one minute, and noting that dilution found to be effective in killing the insects. At least three insects should be used for each test and the test should be repeated with the effective and the nearest non-effective dilution at least three times to eliminate errors due to variations in the resistance of the insects.

COMPARISON OF CREOSOTE OIL DIPS—INSECTICIDAL VALUES.

Test insect—Bedbug.

		1st Test.	2nd Test.	3rd Test.
No. 1	1–200	Alive.		
	1–100	Alive.		
	1–50	Alive.		
	1–33	Alive.		
	1–20	Alive.....	Alive.....	Alive.
	1–16	Dead.....	Dead.....	Dead.
No. 2	1–200	Alive.		
	1–100	Alive.....	Alive.....	Alive.
	1–50	Dead.....	Dead.....	Dead.
No. 3	1–1000	Dead.....	Dead.....	Dead.
	1–1500	Alive.		
	1–1200	Alive.....	Alive.....	Alive.

Official Dilution:

No. 1—1 in 76.
No. 2—1 in 73.
No. 3—Not permitted in official dipping for sheep scab.

Insects fairly uniform in size will vary less in resistance than might be expected. Apparently, those which seem to be exceptionally resistant are ones best protected by adhering air bubbles. It is, therefore, necessary to agitate the tube containing the test insects while immersed in the solution to detach these air globules which prevent intimate contact with the insecticide.

It is true this method will not detect with exactness the difference between

two dips which differ only by 10% in the amount of oil contained in an emulsifiable form, but it will determine that dips differ in efficiency and that this difference is not due to the amount of oil contained, so much as to the character of the oil and to the manner of its combination.

When a creosote oil dip in a dilution of 1 in 250 of water will effectually eradicate sheep scab from a flock badly infected, and is of such a composition as not to come within the ruling and approval of the government experts, they have evidently overlooked the important points of this class of insecticides.

By the process of assay described, this very efficient dip (No. 3) would have been found to contain resin, alkali, water and creosote oil in almost the same proportions as the average dip on the market, but deficient in the ingredient which is considered of utmost importance. For this reason, it would probably not be permitted for use in any official dipping for scab.

No satisfactory information has been obtained on the points as to exactly how these insecticides act and why the physical condition of their dilutions, if it be physical, makes them so efficient. While these questions are unanswered and a rational chemical method is, therefore, not possible, these products evidently should be classed with those requiring a biological standardization. Such a method is required for serums, vaccines and some important animal and vegetable extracts of which even more is known chemically than is known of creosote oil. It is, therefore, reasonable to suggest that until there is more definite information on the points in question a similar method of valuation should be applied to this most important class of insecticides.

Detroit, Michigan, April 20, 1909.

*Presented before the Section of Entomology at the Boston meeting of the International Congress of Zoologists, June, 1907.

THE APPLICATION OF THE ROMANOWSKY METHOD OF STAINING TO SECTIONS.

FRANK A. MCJUNKIN, M. D.

Grassi and Feletti [1], in 1891, succeeded in staining the chromatin of the malarial parasite by the prolonged application of a methylene blue solution, one drop of the saturated alcoholic solution to the watch-glass of distilled water. Romanowsky [2] later in the same year recommended a methylene blue-eosine solution for staining films of malarial blood, which colored the chromatin of the parasite red, the protoplasmic portions blue. This specific differential staining of chromatin is common to the many polychrome methylene blue solutions subsequently recommended. Nocht [3], Reuter [4], Leishman [5], Wright [6], Giemsa [7], and Marino [8] developed modifications, recommended for the staining of blood films and smears containing bacteria.

Unna [9], early in 1904, reported the results of sections stained with polychrome methylene blue, and various combinations of methylene azure (Giemsa). The gross appearence of all sections was blue or blue-violet with blue or blue-violet nuclei. The tissue with which he worked contained no protozoa. Christophers [10] stained sections of organs from cases of "tropical spleno-megaly," containing the "Leishman-Donovan bodies" with a polychrome solution. Leishman [11] later this same year published a method for staining chromatin in sections. He was not able to get good results by the method of Christophers owing to the shrinkage of the tissue brought about by the drying to which it was subjected. Previous to this time he had failed to get chromatin staining in sections with his polychrome stain and thought that a chemical change was produced in the tissue by the hardening and embedding which made it impossible. He cuts 5 micron sections and after removal of paraffin with xylol, and passage through alcohol places on them fresh blood serum for five minutes, blots off the excess and allows the remainder to dry on the preparation. He then places on the section a solution composed of two parts of "Leishman stain" and three parts of distilled water for one and a half hour, renewing the solution once or twice during this time. The section is now differentiated in 1–1500 acetic acid and a 1–7000 sodium hydroxide, dehydrated in absolute alcohol, passed through xylol and mounted in balsam. He remarks that this method induces chromatin staining which resists the decorization of absolute alcohol, although he qualifies this statement by remarking that the red chromatin of the cell nuclei is often changed to blue by the action of the alcohol. He worked with sections containing Tr. brucei, the nucleus and micronucleus being stained red, while the protoplasm was at times blue. Nicolle [12] in working with Leishmania infantum stained sections with a Giemsa solution followed by 2% tannin, absolute alcohol, xylol, balsam. His plates show the two nuclear bodies chromatin-stained while the protoplasm is unstained.

The method which I shall now describe was developed while attempting to stain Leishmania infantum in sections of spleen, liver, etc. Blood films and smears containing protozoa are ordinarily placed in the polychrome-eosine solution which is in use in this laboratory for twenty to forty minutes with one change of solution, chromatin and differential staining being well brought out in this time. Sections when treated in this way show only

methylene blue staining. Even when the sections were subjected to the action of the stain for twenty-four hours with several changes of the solution no chromatin staining resulted. The temperature of the staining solution was now raised by placing the solution containing the preparation in the hot-room at 35° C.* When removed at the end of one hour and examined in water the nuclei of the cells showed a red chromatin stain, the protoplasm being blue. The attempt was made to dehydrate in absolute alcohol but a momentary dip changed the red in the chromatin to blue. After drying in the air, even in 3 micron sections, the structure of the tissue worked with was destroyed owing to the shrinkage. After placing the sections in 2% tannin solution it was found that they could be hurriedly passed through absolute alcohol, to xylol and balsam. The best results have been obtained by placing the solution containing 3 micron sections in the hot-room at 35° for one hour and twenty minutes, renewing the solution at the end of forty and eighty minutes respectively. They are then washed in water—if quite blue wash in 1-1000 acetic acid until pink—and placed in a 2% tannin solution for ten to forty minutes. The tannin not only makes dehydration in alcohol possible but also differentiates, taking out the excess of blue. The tannin solution is washed off with water, the excess of water removed by blotting, and the preparation hurriedly passed through absolute alcohol to xylol and mounted in balsam. Sections of spleen, liver, and lymph-gland containing Leishmania infantum have been successfully stained by this method, the large and the small chromatin masses staining violet, the protoplasmic body of the parasite a robin's egg blue. Sections of lung of an owl infected with *H. ziemanni* stained by this method show the chromatin of the parasite stained a violet red, the protoplasm blue.

It would seem then, at least in the case of some polychrome solutions, that it is necessary to raise the temperature of the staining fluid in order to get chromatin staining, and that insolubilization in some fluid such as tannin is necessary before dehydration in alcohol is possible.

I wish to express my indebtedness to Dr. F. G. Novy for the suggestions which led to the development of this method and to Dr. G. Carl Huber for the loan of apparatus used in cutting sections.

Hygienic Laboratory, U. of M., Ann Arbor, March 31, 1909.

*Note.—The Borrel staining glass was found to be well adapted for this procedure. The section was fixed on a slide near one end and placed in the solution in the cylinder which was then placed in the hot room. The solution may be renewed by washing the stain out of the glass under the tap.

[1]Grassi and Feletti. Centrabl. f. Bakt., 1891, X, p. 517.
[2]Romanowsky. St. Petersburg, 1891. Zur Frage der Parasitologie and Therapie der Malaria.
[3]Nocht. Centrabl. f. Bakt., 1898, 24 p. 839; 1899, 25, p. 764.
[4]Reuter. Munch. Med. Wochensch., 1901, 48, p. 1261. Centralbat. Bakt., 1901, 30, p. 248.
[5]Leishman. Brit. Med. Jour., 1901, 1, p. 635. Brit. Med. Jour., 1901, 2, p. 757.
[6]Wright. Jour. Med. Res., 1902, 7, p. 138.
[7]Giemsa. Centrabl. f. Bakt., 1902, 31, p. 429; 1902, 32, p. 307.
[8]Marino. Ann. de L' Inst. Pasteur, 1904, 18, p. 761.
[9]Unna. Monatsh. f. Prakt. Dermatol., 1904, 38, p. 119.
[10]Christophers. Sc. Mem. by Officers of the Med. and sanitary Dept. of Gov. of India, 1904.
[11]Leishman. Jour. Hyg., 1904, 4, p. 434.
[12]Nicolle. Archives de L' Inst. Pasteur de Tunis, 1908, 1, p. 17.

UNDETECTED CASES OF NASAL DIPHTHERIA.

P. M. Hickey, M. D.

From the attempt which the profession is making to stamp out diphtheria by the isolation of patients afflicted with that disease and by the liberal use of antitoxine both as a curative and prophylactic, we find that a marked diminution of cases has resulted.

However, in spite of the recognition of typical clinical cases and their proper treatment, we find cases occurring in individuals and in families where the history of contagion is difficult to trace. In the pharynx and larynx where the adjacent lymphoid tissue makes the absorption of the toxic products very evident, the general condition of the patient is usually sufficient to call attention to a systemic disease, even where the local symptoms may be such as not to be very prominent.

One of the ways by which diphtheria is spread, in the writer's opinion, is that nasal diphtheria is very frequently unrecognized, and owing to the mildness of the disease may run a long course, giving rise to the infection of many with whom the case comes in contact. The nose may be infected and the culture made from the nasal secretion may show a pure growth of the Klebs-Loeffler bacillus, and yet the constitutional symptoms may be so slight that the clinical picture is often interpreted as that of a simple coryza. The following cases may illustrate the point which the writer would strive to make prominent.

Case I. In September, 1907, the writer was asked to see a case in consultation, with reference to the removal of adenoids for difficult breathing. The patient was a child of four years of age, and upon talking with the mother it was found that the breathing up to three weeks previous had been quite free, with no symptoms of nasal obstruction. At that time the child was supposed to have contracted a cold, since which time the respiration had been principally oral, with attacks of choking at night.

Examination of the case showed a thick discharge, principally from the left nostril. This was evidently of an acrid, irritating nature, as the skin of the upper lip and the edge of nose were all inflamed. Inspection of the throat showed no membrane upon the larynx or tonsils, and there was no hoarseness to indicate any pharyngeal involvement.

Owing to the acuteness of the condition, its short clinical history, and the fact that the discharge was principally unilaterally, it was decided to make a culture from the nose. This was done, and the report from the Board of Health showed pure growth of Klebs-Loeffler bacillus. The child was given antitoxine and the other children of the family were given suitable immunizing doses, and the trouble was ended.

Case II. A little girl, age 7, child of a physician on the east side, was brought to the office by her father for an acute cold. She gave no history of a severe illness, having manifested only a slight indisposition for about two weeks. This had been accompanied by a slight rise of temperature. The discharge from the nose was seen to be principally from the left nostril and of a very thick nature with a slight tendency to bleeding.

Examination of the pharynx and larynx was negative. As the child was old enough to exclude the introduction of a foreign body into the nose,

the finding of a unilateral nasal discharge was grounds for a probable diagnosis of nasal diphtheria. This was confirmed by the report of the culture, which showed the Klebs-Loeffler bacilli present.

The use of antitoxine brought about a speedy cessation of the symptoms and the child made an uninterrupted recovery. Here the patient was a child of a physician, whose work had brought him in contact with many cases of diphtheria, and yet the constitutional symptoms were so slight that the grave disease had not been suspected.

Case III. W. F., age 5 years, was brought into the office by his mother, who said that he had been suffering from a cold in the head for a few days. Here the examination of the nose showed a well marked unilateral discharge with no evidences, however, of any membrane. There was absolutely no history in this case of any malaise, the child showing no temperature and eating quite heartily. As the boy had been subject to colds before, it was thought perhaps that this was a slight coryza, and a culture was not taken, but a simple mild ointment for the nose was prescribed.

The second day after, the mother returned with the child and said that she fancied that there was something the matter with her own throat. A small patch was visible on the left tonsil of the mother. A culture was taken from this patch. The child of five years was given a second examination, and as the discharge from the left nostril still continued a culture was made from this. Another child, aged 3, in the same family, was then examined and a culture taken from her nose, although there were no symptoms. Reports from the three cultures, from the tonsil of the mother and from the noses of the children, showed Klebs-Loeffler bacilli present in each case.

The history of infection in this family was interesting, as being evidently of an intermediate nature. The only exposure, that could be traced was as follows: The chauffeur employed by the family was a married man, and his family lived in another part of the city. His own child had had diphtheria a month before, and he had been home taking care of the child. After the recovery of his child he returned to his work, and the children of his employer were thrown into somewhat close contact with him for some time.

If we wish to stamp out diphtheria, we must make cultures from not only throats which are suspicious but also from cases where the nasal discharge is of such a nature as to warrant suspicion.

The point which the writer has found of weight in considering a case is, first, the presence of a unilateral discharge. If a foreign body can be ruled out, as it frequently can by a thorough examination of the nose, the clinical history is of sufficient weight to warrant the taking of a culture. If there is a discharge from each nostril attended by bleeding for which no adequate cause can be given, a culture should also be taken.

If the profession will get after these cases of nasal discharge which present points suspicious of a Klebs-Loeffler origin, we will do much towards stamping out this disease in our community.

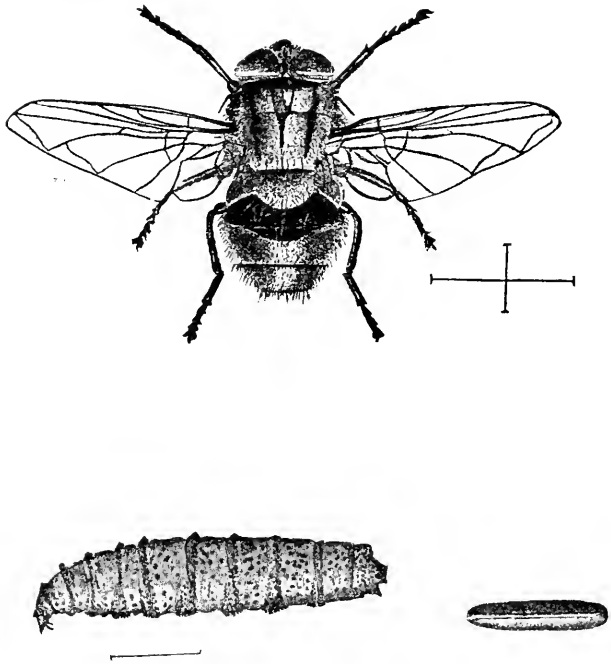
Detroit, Michigan, April 20, 1909.

THE SCREW-WORM FLY WITH THE REPORT OF A CASE OF MYIASIS NARIUM.

ALEXANDER W. BLAIN.

(Abstract.)

Myiasis or the invasion of the human subject by members of the Diptera (flies) has received but scant notice in our larger medical text-books and in medical literature in general. As a matter of fact the disease is comparatively common in man, especially the inroads of the Screw-worm Fly (*Compsomyia macellaria-Fab*).



Compsomyia macellaria.

FIG. 1—adult, FIG 2—larvae, FIG. 3.—egg, (after Francis).

In the south and south-west the attacks upon horses, sheep and cattle have been noted by various writers. (In Kansas by Snow, in Louisiana by Morgan, in Mississippi by Weed and in Texas by Francis.) This past summer a veterinary surgeon of San Bernardino, told me the condition was not rare in southern California.

The recognition of the injurious nature of the insect appears to have been in the early days of American settlement, and its description has occupied the attention of numerous naturalists. The distribution of the species is

credited by Osborne (*Insects Affecting Domestic Animals*, Washington, 1906) to all Americans between Patagonia and Canada but the territory within which the greatest damage occurs is within tropical and subtropical belt. Professor Petit of the Michigan Agricultural College informs me that he has not met with the insect in this state.

The fly is a small insect less than half an inch in length. The eggs are deposited in decaying matter or a wound, at least three or four hundred being deposited by a single female within a few moments, the eggs hatch in a few hours. The larvæ or maggot is a whitish, footless grub, slender and quite active, burrowing into the tissue of the affected animal or into the mass of putrid flesh or decaying matter that furnishes it food. When mature they escape from the mass of matter or wound in which they have developed, and bury themselves in the ground to transform.

This past summer while on a trip through the western states I was enabled to follow one of these cases of human myiasis which occurred in the practice of Dr. R. N. Looney of Prescott, Arizona, during my visit there. The patient, a miner, Italian, 36 years of age, was working about the top of a mine shaft when a fly entered his nose. He knocked it out and paid no further attention to it until two days later (June 15, 1909) a terrible frontal headache developed which caused him to consult a physician. Later a serosangniuous foul smelling discharge developed.

A diagnosis of myiasis narium was made and the nose treated with swabs of pure chloroform. Several maggots came away. The following day the operation was repeated with the same result. His cure was uneventful, twenty-five maggots were removed altogether.

Yount (*Journ. Am. Med. Ass'n*, 1907) records 23 cases occurring in Arizona in one year (1905). Eighteen showed nasal myiasis and five myiasis of some other site. The mortality for all was 15 per cent. For the nasal cases alone the mortality was over 22 per cent. Certainly enough to demonstrate the serious nature of the disease. Over 200 maggots have been removed from some patients.

The prevention of the disease is easier than the cure. Patients with wounds, abrasions or catarrhal conditions of the nose and ears should be looked after. In all parts of Arizona the treatment of these cases was about the same, chloform differing only in its method of administration being the drug of choice, varying in strength from 25 per cent in oil to the pure drug. The maggots should be searched for immediately afterwards and removed with forceps.

In Michigan, maggots of various flies occasionally attack wounds in animals. I have taken as many as thirty from the wing of a domesticated swan.

Occasionally ulcerated wounds, as advanced carcinoma of the breast, are infected. It is probable that the maggot is introduced directly as in applying oatmeal or cornmeal poultice. I was recently informed of several maggots being removed from a sealed package of one of the well known breakfast foods.

Under proper surgical treatment such an accident would be impossible I have never heard of maggots entering wounds in a well regulated hospital.

1105 Jefferson Ave., East Detroit, Mich., April 1, 1909.

NOTES ON MICHIGAN REPTILES AND AMPHIBIANS.

ALEXANDER G. RUTHVEN.

Notwithstanding the fact that Michigan is situated in eastern North America, where most of the biological work has been done in this country, it is painfully evident to the student that the data at present available on our fauna leaves much to be desired. This is less true as regards the molluscs and birds, but of the other groups, both vertebrate and invertebrate, much remains to be known before the faunal problems of this region can be comprehensively attacked. The biological surveys carried on by the University of Michigan Museum in 1904 and 1905, and by the State Biological Survey in 1906 and 1908, have done much to increase our knowledge of the fauna of Michigan, and it is the purpose of this paper to place on record some additional data on the reptiles and amphibians of the State, that have accumulated at the Museum mostly as the result of these surveys.

Rana cantabrigensis Baird. The Michigan Wood-frogs have usually been listed as *R. sylvatica*. The writer [1] listed a series from the Porcupine Mountains as *sylvatica*, in 1904, but these were later, with an Isle Royale specimen, determined as *R. cantabrigensis* by Dr. Stejneger. [2] Those from the southern peninsula have always been listed as *R. sylvatica*.

The writer has recently, in working up the collection from Huron county, had occasion to go over the whole matter, and it developes that all the Michigan Wood-frogs, both from the northern and southern peninsulas, are to be referred to *R. cantabrigensis*, *R. sylvatica* being apparently excluded from our limits. *R. cantabrigensis* may be distinguished from *R. sylvatica* by its short hind-legs. In the former the length of the hind-leg to the heel equals the distance from the anus to some point in front of the eye, only occasionally extending beyond the snout and then only slightly. In *R. sylvatica* the hind-leg reaches considerably beyond the end of the snout when the limb is pressed against the side. Dr. Stejneger has kindly confirmed my determinations by a comparison of specimens from southern Michigan with typical specimens of *sylvatica* from the east.

Thamnophis butleri, (Cope). The biological survey of 1908 brought back specimens of the Butler Garter-snake from Stony Island and Rush Lake, Huron county, thus extending the known range considerably to the northward. The most northern record previously known was Pontiac, Oakland county. [3] It was apparently quite rare in the sand region along the south shore of Saginaw Bay.

Elaphe vulpinus (Baird and Girard). The only Michigan record of the Fox-snake, known to the writer, is Grosse Isle, Wayne county, [4] in the extreme southeastern part of the State. There is a single specimen in the Museum from Pearl Beach, St. Clair county, and Mr. C. K. Dodge, of Port Huron, has recently sent in a specimen from Harsens Island (St. Clair county), Lake St. Clair. The expedition of 1908 found it to be quite common in the sand region along the south shore of Saginaw Bay (Huron county).

[1] Sixth Ann. Rept. Michigan Academy of Science, p. 191.
[2] Michigan Geol. Survey, Ann. Rept., 1905, p. 110.
[3] U. S. National Museum, Bull. 61, p. 92.
[4] Cope, Rept. U. S. National Museum, 1898 (1900), p. 832.

Heterodon platyrhinus Latreille. The status of the Hog-nosed Snake in the State is questionable. Smith[5] has recorded it from Ann Arbor; Gibbs, Notestein and Clark[6] list it from Wayne, Kalamazoo, Van Buren, Allegan and Barry counties, and Notestein[7] states that it is "quite common in Michigan." Smith's record for Ann Arbor must be held in question, as the specimen is not in the Museum, and none have since been taken in this vicinity. The county records of Gibbs, Notestein and Clark are probably authentic, but, as these writers fail to state the source of the original records, the determinations cannot be verified, unless one is willing to accept the statement in the introduction to their paper that their list "contains all species whose occurrence has been verified and vouched for by at least one of us." It must be said, however, that in view of the preference of this snake for dry sandy habitats we should expect to find it along this (western) coast of Michigan. Notestein's statement that it is common in Michigan is certainly not true, if we take it that he means generally throughout the State or even in the southern peninsula, for we have failed to find it at Ann Arbor. Clark[8] does not record it from Eaton county, and, so far as known to the writer, it has never been recorded from the northern peninsula.

In view of this uncertainty concerning the occurrence of the Hog-nosed Snake in the State, the following data that has accumulated at the University of Michigan Museum during the past few years is of interest: In 1903 Prof. Jacob Reighard and Mr. N. A. Wood, of the University of Michigan, while on a collecting trip, captured a Hog-nosed Snake on the Au Sable River, about six miles above McKinley, Oscoda county. This specimen subsequently escaped. Mr. P. A. Taverner, Highland Park, Michigan, has also informed me that he has seen a specimen at Pearl Beach, St. Clair county. (The writer may add that Mr. Taverner is perfectly familiar with this snake.) Even more satisfactory than these records by reliable observers are the specimens which have been obtained. The biological survey of 1908 found it to be not uncommon along the south shore of Saginaw Bay (Huron county), and brought back a number of specimens. During the same summer Miss Crystal Thompson, University of Michigan, captured one at Port Austin, and another has recently been received from Miss Cora Reeves, that was taken near Manistee, Manistee county. Few as these records are they seem to indicate that the species occurs in the sandy areas along both coasts of the State.

Chrysemys bellii (Gray). Recently in working over the Michigan turtles in the collection of the University Museum, the writer has found that he erred in classing Porcupine Mountain specimens as *C. marginata* in 1905 and 1906.[9] *C. marginata* has thus far been taken only in the southern peninsula, the northern peninsula specimens in the collection (all from the Porcupine Mountains) being *C. bellii*. These turtles are superficially very similar, but *C. bellii* may be distinguished from *C. marginata* by the very large size of the plastral blotch, and by the presence of light lines on the costal and vertebral scutes. In *C. marginata* also the costal and vertebral scutes have quite constantly rather regular yellow margins, which in *C. bellii* are usually wanting, or when present are much more irregular than in the eastern form.

Ann Arbor, April 1, 1909.

[5]Supplement to Science News, Vol. 1, No. 23, p. vi.
[6]Seventh Annual Report Michigan Academy of Science, p. 110.
[7]Seventh Annual Report Michigan Academy of Science, p. 118.
[8]Fourth Annual Report Michigan Academy of Science, pp. 192–194.
[9]Sixth Annual Report Michigan Academy of Science, p. 191. Michigan Geological Survey, Annual Report, 1905, p. 112.

THE EARLY DEVELOPMENT OF NEUROFIBRILLAE IN RANA AND AMBLYSTOMA.

H. M. MacCurdy.

(Abstract)

The observations of Harrison on the living developing nerve cell in the larvæ of Rana, and of Held on the development of neurofibrillae in Amphibian and other embryos, suggest the possibility of correlating the development of structure and function in the early stages of the growth of the individual. Held has described neurofibrillae in the neurblasts of the larvæ of Rana fusca 5.5 mm in length, in axolotl larvæ 5 mm in length, in 3 and 4 days old duck embryos and in later stages in trout embryos.

In the study of the developing nerve cells in embryos of Rana pipiens, R. cantabrigensis, and Amblystoma, I have found neurofibrillae in the neuroblasts as early as it is possible to distinguish the outgrowing nerve fiber.

In embryos of R. cantabrigensis fibrillae are present at the end of the second or the third day in larvæ scarcely 3 mm. in length. In R. pipiens they appear later, in larvæ 4 mm. in length, and in Amblystoma* they arise somewhat later still since the development is slower in the latter form. So far as it has been possible to make out, neurofibrillae first appear in the ventrolateral portion of the neural tube giving rise to the mid brain. Fibers bearing fibrillae extend ventrally connecting the two sides, and they also extend posteriorly along the ventral surface of the two sides of the developing neural tube with no direct fiber connection at first between the two sides ventrally so far as can be seen. Neurofibrillae are also present in the first fibers to be seen in the developing optic nerve, in which they can be seen extending to the retinal elements as soon as the latter are sufficiently differentiated to be recognized.

Neurofibrillae, therefore, are present in the nerve elements before the latter assume their regular function, and it is reasonable to assign to the fibrillae some part in the functioning of the nerve elements when normal body movements begin or when the embryos first show a response to tactile stimuli.

The order of the origin and development of the nerve fibers tracts and neurofibrillae is in general accord with the origin and development of the first observable normal body movements of the embryos, and precedes those movements in point of time. The same may be said of the first responses to the tactile stimuli as far as they have been observed. The presence of conduction paths determines the reactions.

*A. jeffersoniamem.

NOTE ON A DOUBLE SNAIL, CAMPELOMA SP. (decssa, Say.) (Abstract.)

H. M. MacCurdy.

While examining a number of specimens of Campeloma taken in Pine River at Alma, a young double snail was found together with other young snails of normal form. The double snail possessed two separate dextral shells slightly smaller than the average in size for the normal shells, two opercula, two pairs of eyes and two pairs of tentacles. To what extent the internal organs were duplicated or shared in common is not known. The left side of the foot of each individual was closely united with the left side of the other in such a manner as to bring the forward movements of each individual in more or less direct opposition to the movements of the other. Locomotion was thus impeded though the dominating influence of one which was slightly larger than the other always determined the direction of movement. The snails were approximately 10 mm. in diameter and lived only a few days. The unusual occurrence of such a form together with other peculiarities renders the specimen worthy of a more complete description.

Alma College, Mar. 31, 1909.

THE GERM-CELL DETERMINANTS OF CHRYSOMELID BEETLES.

Part I. The Germ-Cell Determinants.[1]

Part II. The Results of Removing the Germ-Cell Determinants.[2]

By R. W. Hegner.

Part I. The Germ-Cell Determinants.

This paper is based on the study of the embryology of four chrysomelid beetles. Most of the work was done on the eggs of *Calligrapha multipunctata*, a beetle that lives on the leaves of the long-leaved willow; similar conditions were also found in the eggs of two other members of this genus and in the potato beetle, *Leptinotarsa decemlineata*.

At the time of laying (Fig. 1), the eggs of these beetles consist of a large central mass of yolk globules (y) and a thin peripheral layer of cytoplasm (khbl) which is connected with the cytoplasm filling the interdeutoplasmic spaces. Polar body formation is taking place at this time, and there are one or more sperm nuclei near the anterior end of the egg. The peripheral layer of cytoplasm is homogeneous except at the posterior end of the egg. A disc shaped mass of granules (pd. g) is present at this point suspended in the outer cytoplasmic layer. I have called this mass of granules the pole-disc and the individual granules, the germ-cell determinants. The pole-disc covers about one-eighth the area of the posterior end of the egg. The granules stain deeply in haematoxylin.

The cleavage products in the eggs of these beetles migrate from within the central yoke mass, where the first divisions take place, to the periphery. Here they fuse with the cytoplasm; cell walls are formed and a blastoderm is produced of a single layer of cells. Conditions are not the same at the posterior end of the egg. At this point (Fig. 2) a certain number of the cleavage products come in contact with the germ-cell determinants. These nuclei do not remain at the periphery to become the centers of blastoderm cells; but, gathering a covering of granules about them, they continue their migration until they have become entirely separated from the egg. These cells, the primordial germ-cells (pc), now lie between the egg and the vitelline membrane. A superficial view of the posterior end of an egg at this time reveals the fact that there are 16 germ-cells present and that these 16 cells have carried practically all of the germ-cell determinants out of the egg. These 16 germ-cells by two rapid divisions increase to 64. During the divisions the granules are equally distributed among the daughter cells. No further divisions take place until a late stage in embryonic development.

The germ-band arises as follows. The blastoderm on the ventral surface of the egg thickens to form the ventral plate; a longitudinal concavity, the ventral groove, appears in the center of this plate. The ventral groove becomes deeper at the posterior end of the egg and the germ-cells are drawn into this concavity by the contraction of the ventral plate. The ventral

[1] A full account of the origin and early history of the germ-cells in chrysomelid beetles is now in press (Journal of Morphology).

[2] A preliminary report on this subject appeared in the Biological Bulletin, Vol. 16, No. 1, December, 1908.

groove now is overgrown by the amnion, and the germ-band grows around the posterior end of the egg and up on the dorsal surface carrying the germ-cells with it. The germ-cells now begin to migrate from the amniotic cavity into the embryo through an opening in the ectoderm which we may call the germ-cell canal. They are amoeboid (Fig. 3) and their pseudopodia are pointed in the direction of their migration. The pole-disc granules in these germ-cells have been getting smaller during the migration and this is the last stage in which they can be clearly recognized. The germ-cells eventually all pass into the embryo. Here they separate into two groups, one on either side of the germ-band; each group later becomes a germ-gland. The sex of the embryo may be recognized before hatching by the shape of the germ-gland.

The history of the primordial germ-cells as outlined above gives, I think, reasonable ground for the following conclusions.

I. All the cleavage nuclei in the eggs of the above named beetles are potentially alike until in their migration they reach the periphery. Then those which chance to encounter the granules of the pole-disc are differentiated by their environment, i. e. the granules, into germ-cells; all the other cleavage products become somatic cells. The granules of the pole disc are therefore either the germ-cell determinants, or the visible signs of the germ-cell determinants.

II. The primordial germ-cells pass entirely out of the egg and later migrate into the embryo by means of amoeboid movements.

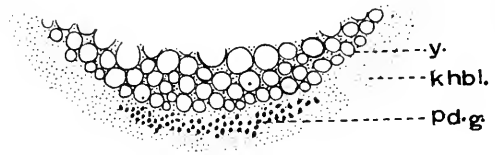
III. The sex of the embryo can be determined before hatching.

Part II. The Result of Removing the Germ-Cell Determinants.

A number of experiments were made in an effort to extract the germ-cell determinants or primordial germ-cells from the egg. Eggs in the stage shown in Fig. 1 were punctured with a needle in the center of the posterior end, and a drop of cytoplasm containing the germ-cell determinants allowed to flow out. Eggs thus operated upon produced embryoes and larvae which were apparently normal but on examination were found to lack either all of the germ-cells (Fig. 4) or to contain a fewer number than are produced normally. All of the germ-cell determinants probably were not removed from those embryoes which still contained germ-cells.

Other eggs were operated upon when they had reached the stage represented in Fig. 2. The embryoes and larvae which developed from these eggs either lacked germ-cells entirely or possessed a fewer number than the normal. The results of these experiments strengthen the conclusions reached by morphological methods.

Zoological Laboratory,
University of Michigan, April 1, 1909.



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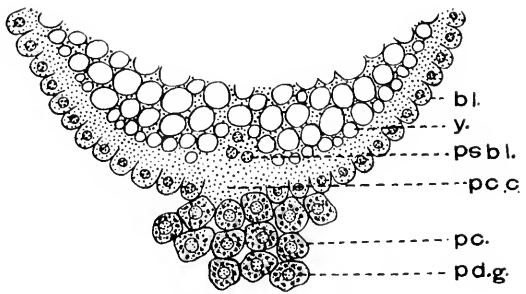
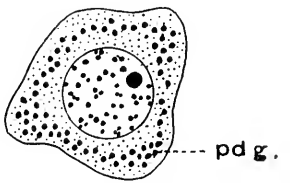


FIG. 2.



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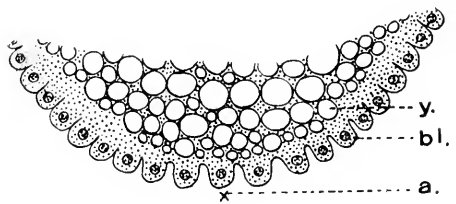

F 4.

Fig. 1. A portion of the posterior end of an egg of *C. bigsbyana* in longitudinal section showing the arrangement of the pole-disc granules(*pd. g*). *y*=yolk; *khbl*=peripheral layer of cytoplasm.

Fig. 2. Longitudinal section through the posterior end of an egg of *C. bigsbyana* showing the primordial germs-cells (*pc*) containing pole-disc granules (*pd. g*). Nuclei which are prevented from forming blastoderm cells produce a pseudo-blastodermic syncytium (*psbl*). The letters *pc. c* indicate the canal through which the germs-cells later migrate into the embryo. *bl*.=blastoderm. *y*=yolk.

Fig. 3. A single primordial germ-cell showing pole-disk granules. (*pd. g*).

Fig. 4. Longitudinal section through the posterior end of an egg of *C. lunata*. The letter *a* indicates where germ-cells would be found in an uninjured egg. *bl*=blastoderm. *y*=yolk.

THE EFFECTS OF CENTRIFUGAL FORCE UPON THE EMBRYONIC DEVELOPMENT OF SOME CHRYSOMELID BEETLES.[1]

R. W. Hegner.

Centrifugal force was first employed as a method in experimental embryology by Roux in 1884. The real value of the centrifuge, however, was not fully recognized until a few years ago. It has recently been used to test a number of conclusions reached by morphological methods. Of these I may mention the following: Roux (1884), Born (1885), O. Hertwig (1897+), Morgan (1902+), and Gurwitsch (1904) have subjected the eggs of frogs and toads to centrifugal force of various strengths. Their results seem to show that gravity has no effect upon the embryonic development of these Amphibians, that yolk is heavier than cytoplasm, that strong centrifugal force causes the development of abnormal embryos due probably to the fact that certain parts of the egg are rendered incapable of development, that the pigment does not act as a formative substance, that as an egg advances in development it becomes less susceptible to the influence of centrifugal force, and that protoplasm must be in a fluid condition to allow the yolk granules to be driven through it and still be capable of development. Experiments have also been made to learn the specific gravity of the various substances in the egg (Lyon, 1907 in *Asterias, Arbacia, Chaetopterus, Cynthia, Phascolosoma* and the common garden spider), to trace substances from the fertilized egg into the cleavage cells (Lillie, 1906 in *Chaetopterus*), to study the polarity of the egg (Lillie, 1909 in *Chaetopterus*) and to investigate the determination of sex in Rotifers (Whitney, 1909).

This paper is based upon the results obtained from a number of experiments with eggs of Chrysomelid beetles. Eggs of the willow leaf-eater, *Calligrapha multipunctata*, were used more than any other but eggs of *C. bigsbyana, C. lunata, Leptinotarsa decemlineata* and *Lema trilineata* were also employed. The eggs of these beetles are always laid with their posterior ends fastened to a leaf of the food plant. They can therefore be definitely oriented. During the experiments they were placed in cavities in a block of paraffin, fastened in the tube of a centrifugal machine and rotated at various speeds usually about 2000 revolutions per minute. They were taken from the machine at the desired time and either fixed at once or allowed to develop. I shall describe below the results obtained with eggs in early cleavage stages, with eggs laid by centrifuged beetles and with the embryos which developed from them. A brief review will then be given of the conclusions reached from a study of the effects of centrifugal force upon eggs in various stages of development.

A description of the structure of a freshly laid egg of *C. bigsbyana* will be found in another paper published in this report so I need not repeat it here. After an egg in the early cleavage stage has been centrifuged for an hour or more, three distinct regions are visible, a colorless cap at the outer end, a bright orange region at the inner end and an intermediate zone yellow at the outer end and becoming less brightly colored as the inner layer is

[1] A detailed account of all the experiments referred to below is now in press (Jour. Exp. Zool.)

approached. The orientation of the egg has no effect upon the production of these zones since they appear when either the anterior or the posterior pole is toward the center of rotation. When centrifuged eggs are fixed immediately after being taken from the machine they exhibit in sections three regions which differ greatly in their composition. The bright orange zone of the living egg is seen to be made up of irregular oil globules imbedded in cytoplasm which has risen to the light end of the egg. I have given to this the name "vesicular zone." The colorless cap at the outer end is composed of a homogeneous mass of granules, the heaviest substance in the egg, which has been driven to the pole away from the center of rotation. I have called this material the "gray-cap." Where the substance of the gray-cap comes from is not known. The comparatively large intermediate zone is a mass of yolk globules, the large heavy spheres being at the outer end and the smaller granules blending with the cytoplasm of the vesicular zone. The nuclei are lighter than the yolk and of about the same specific gravity as cytoplasm. They all concentrate near the inner pole carrying with them the little islands of cytoplasm in which they are normally embedded. Nuclear division proceeds as usual showing that the mitotic figure is not easily disarranged. The germ-cell determinates are heavier than the nuclei and the cytoplasm and move *en masse* toward the end away from the center of rotation.

The eggs of the beetles differ from the eggs which have previously been centrifuged in the absence of cell walls in the early cleavage stages. It is thus possible to obtain results with older eggs and to extend investigations into later developmental stages. Moreover there are no cell walls to hinder the restitution of the substances which have been thrown out of their normal positions. It has been found that "when different substances of the egg are displaced by strong centrifuging they tend to come back to their normal positions unless prevented by partition walls which have formed in the meantime." (Conklin, 1908, p. 94). In beetles' eggs the yolk globules which are the first to become disturbed are also the first to redistribute themselves. The substance of the gray-cap does not become rearranged and probably takes no part in embryonic development. The vesicular zone generally disappears in a short time. When it does not become redistributed an abnormal embryo develops leading one to conclude that this substance is necessary for normal development. When no redistribution takes place in any of the zones a dwarf embryo is produced at the inner end, that is, where the cytoplasm and nuclei have gathered.

The age of the egg when centrifuged has a marked influence upon its later growth. The general statement may be made that the older the egg the more chances there are of its normal development after centrifuging. A large number of experiments with beetles' eggs show that eggs in the blastoderm stage or older always produce normal embryos and sometimes larvae.

The rate of development is apparently not affected by centrifugal force. The average period for the hatching of the eggs of *C. multipunctata* is five and two-thirds days (Hegner, 1908).

Several beetles were centrifuged and the eggs they laid carefully examined. In the majority of cases the eggs showed no rearrangement of materials and the production of embryoes and larvae was not impeded. In one case however, two abnormal embryoes developed from eggs which had been centrifuged within the mother before the germinal vesicles had broken down.

It may be said in conclusion that the eggs of insects, although supposed by many embryologists to be the most highly organized of any animal eggs, may have their contents profoundly disturbed without preventing the production of a normal embryo. The cytoplasm and the nuclei of centrifuged eggs are forced out of their usual positions but often normal development takes place. This would indicate that a high degree of organization does not prevent the egg from adapting itself to changed conditions.

The University of Michigan, April 1, 1909.

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Ann Arbor, April 1, 1909.

SOME LIGHT REACTIONS OF GONIONEMUS.

LOUIS MURBACH.

Its peculiar behavior and its availibility have brought this little jellyfish Gonionemus into quite general use for experimental purposes at Wood Hole, Mass. (1). In the following notes on behavior toward light it is my purpose to record such observations as I have made after finding that the subumbral papillae are not specially sensitive to light (2); and such other observations as seem desirable to decide some points on which other authors are not agreed.

My own experiments have led me to believe that the responses of Gonionemus to light were not as direct as has been maintained, neither that the light, as such, acted directly but that change of intensity, such as would be encountered in the natural environment, is a stimulus, that random movements tend to bring the medusa into a favorable environment. More intense light stimuli such as may be used in laboratory experiments may act directly on muscles and bring about an "avoiding reaction," or inhibition which may bring the animal to rest in an unfavorable environment, such as strong sunlight.

When the medusae are at rest, shading one with an opaque object such as the hand, is sufficient to start movement in a few seconds; again by throwing stronger light on an animal it can be made to move about. Indeed the one or the other of these ways was generally used in my experiments to get motor reactions. These observations confirm Yerkes' (3) recent assertion that "change in the intensity of light stimulates the medusa."

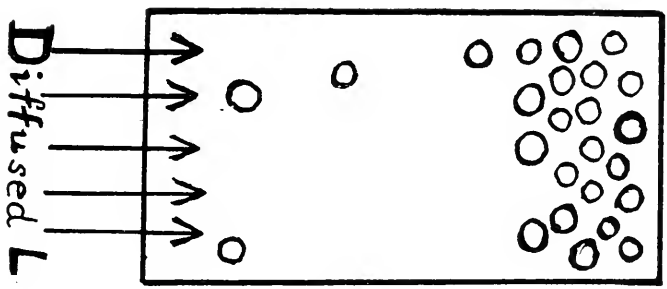
From a carefully planned experiment for the purpose of finding the effect of illumination from one direction Morse (4) p. 684, has found one way in which Gonionemus may get from an unfavorable to a more favorable location when disturbed. Each time on its upward course a medusa in the light end of an aquarium was seen to bend its path a little farther away from the direction of light, and thus ultimately it got to the farther side of the aquarium. The explanation seems promising, since it is based on the natural up-swimming habit peculiar to these medusae when disturbed. But Morse also records a case where the animal swam more directly toward the darker end of the aquarium. On repeating the experiment I found that about one-fourth of the medusae would swim to the farther end away from the light direction, the others *swimming about irregularly*, coming ultimately to the darker region, and some even coming to rest in the brighter end of the aquarium.

A test was made using only a horizontal band of sunlight, the width of the aquarium. Darkening the aquarium momentarily was the means of starting the medusae to swim up through the band of light. Forty-three per cent turned away from the source of strong light, thirty-three per cent toward the source and twenty-four per cenr swam straight through the band. This was simply to learn whether sunlight really causes the medusa to turn as Yerkes (5) p. 284, and Morse (4) p. 683, have maintained. Now it was thought

1. The experiments on which these notes are based were made at the Marine Biological Laboratory, at intervals between other work in the summer. Acknowledgment is due the Director of the Laboratory for continuing to place the necessaty facilities at my disposal.
2. American Jour. Physiol., 1903, Vol. X.
3. Jour. of Comp. Neurol. Psychol., 1906, Vol. XVI.
4. American Nat., 1907, Vol. XLI.
5. American Jour. Physiol., 1903, Vol. IX.

that an oblique band of light would be more decisive (c. f. Fig. 3) as one side of the up-swimming medusa would be stimulated in advance of the other. In this case fifty per cent of the animals turned away from the band of sunlight, forty-one per cent toward it and nine per cent did not respond. I believe that the experiments confirm the conclusion that the medusae can be turned by strong light. A more striking result was obtained with relaxed medusae floating down and striking an oblique band of sunlight, turning to swim up several times.

In these experiments it was noticed that the up-swimming medusae would not always come to the top and some turned back after they had passed the band of sunlight. I do not believe that this is an after stimulation of the light-band, I think it is the counter stimulus of change to lower intensity of light. This view is supported, by the results I got on excluding all possible sources of light; these were reflections from debris in the water, and from a light substratum on which the aquarium stood. The water was filtered and the aquarium made so dark that the medusae could scarcely be seen outside the band of light. Now many of the medusae swam back before reaching the top in their upward course.



Top View
Fig. 1.

Many observations indicate that medusae that have been exposed to light of low intensity will collect temporarily, at least, in strong light. This, I believe, is the explanation of the apparent discrepancy between Morse's [(3) p. 452] and Yerkes' [(3) p. 459] observations on the collecting of medusae in sunlight, Yerkes maintaining that when medusae are first placed in a glazed, white, earthenware dish half of which is shaded they first collect in the sun. His original statement [(6) p. 446] does not specify sunlight.

If then the movements of Gonionemus are not regularly directed by light but it gets into favorable environment by random movements being turned each time it gets into strong light, it would seem a priori, that ray-directing is out of the question. However Morse [(4) p. 684] has decided from an experiment with oblique illumination over the shaded end of an aquarium, because the medusae collect in the ray-direction end of the aquarium rather than in the shaded end, that "the direction of the ray of light is the important

3. Jour. of Comp. Neurol. Psychol., 1906, Vol. XVI.
4. American Nat., 1907, Vol. XLI.
6. American Jour. Physiol., 1902, Vol. VI.

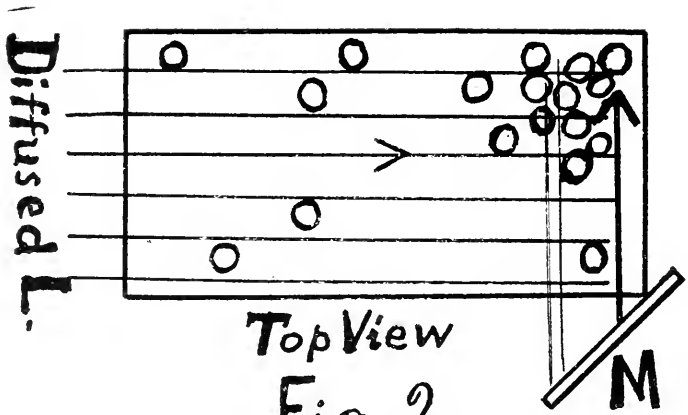


Fig. 2.

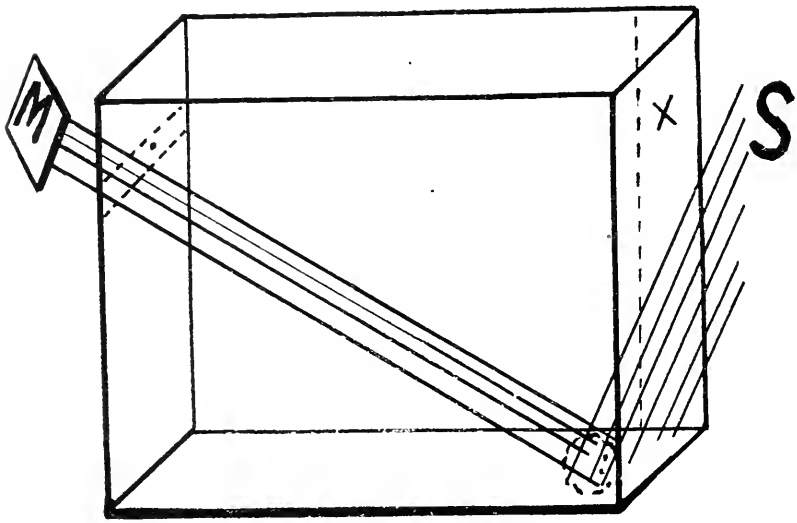
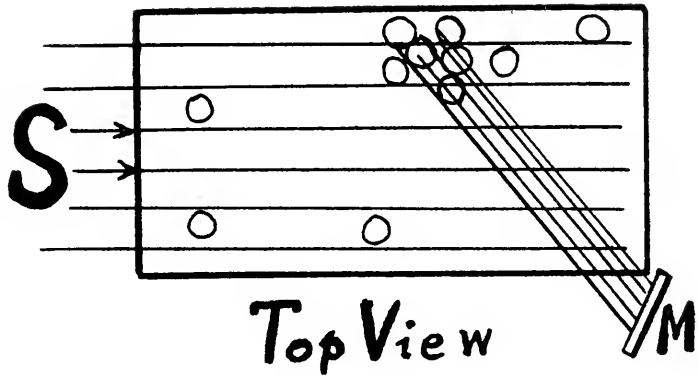


Fig. 3.

factor in orientation." Has he not left out of consideration a very important factor, that of light intensity? Change of intensity has already been shown to be the important stimulus in the ordinary reactions to light. To test whether it was ray direction or intensity that determines where the medusae will collect the following experiments were tried: The aquarium used in previous experiments was placed before an open west window at 3 p. m. in good diffused daylight, Fig. 1. In 15 minutes the majority of the medusae had retreated to the end of the aquarium away from the window. Now a



Top View

Fig. 4.

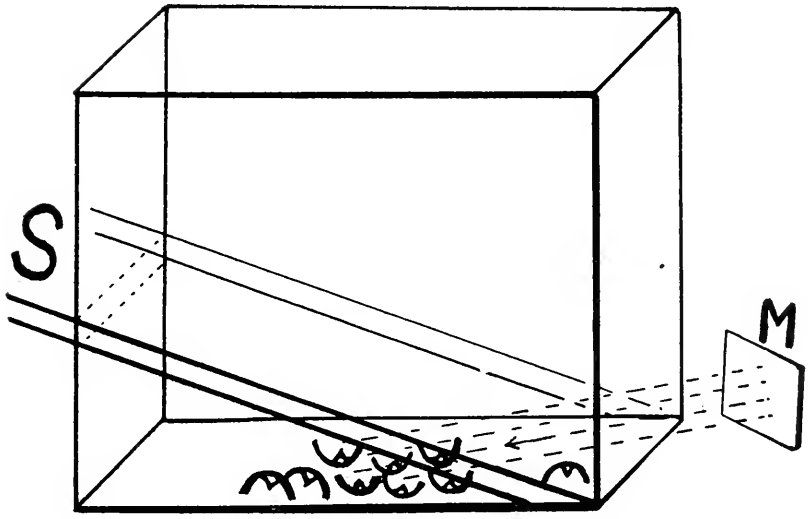


Fig. 5.

large mirror (M. Fig. 2) was placed vertically against one corner of the aquarium away from the window so as to throw light across the end of the aquarium. In fifteen minutes most of the medusae had collected in the opposite corner of the aquarium away from the window and where the light was least intense. The mirror was now placed at this corner and record again made in 15 minutes. Many of the medusae were scattered about, but again there was a larger number collected in the corner farthest from the sources of light. In two other experiments a sort of spotlight effect

was produced, by having the aquarium darkened except at one end, and a vertical strip (X Fig. 3) at one side next the open end so as to throw sunlight across the open end diagonally. There was also a slit near the top of the closed end of the aquarium for a band of sunlight or a mirror beam. The medusae gathered farthest from the source of light when sunlight was passed through the end of the aquarium. Now crossing this sunlight by a beam from a small mirror, through the slit, made the medusae leave the place where the light overlapped, where it was more intense. The position of the sunbeam and mirror was reversed with about the same result. In this case the mirror was held high enough so that its circumscribed area of reflected light fell near the farther corner of the aquarium, leaving a place of high intensity where the band of sunlight fell, but not as high as that where the two overlapped. Other portions of the aquarium seemed to be of too low intensity, as the medusae remained in the lighted portions. The effect of relative intensities was then nicely shown by lowering the mirror so that its beam was projected horizontally across the band of sunlight. (Similar to Fig. 2) Again there were more medusae in the corner farthest from the two sources of light. In a final test sunlight was admitted through a slit near the bottom of the aquarium and the mirror placed back of the aquarium in such a position as to throw reflected light obliquely against the sunlight, as it were. (Fig. 4 and 5). Now the medusae collected some distance from the back of the aquarium in the region of lesser intensity. Ray-directing, seems to me, out of the question.

Some experiments made to determine the height to which Gonionemus would swim after a single stimulation showed such interesting reactions of sudden change of intensity that I give them here, especially since they lead rather naturally to the next section. Eight medusae were placed in a hydrometer jar 72 cm. deep and 9 cm. in diameter. When they had come to rest in the bottom of the jar they were stimulated by darkening the room until the medusae could still be seen. They swam to the top at intervals somewhat irregularly. The shades were now quickly raised and thus the top of the jar was illuminated with strong diffused daylight. Three medusae swam downward so directly as not to touch the sides of the aquarium not varying nine centimeters from their course. Five floated down part way and then two turned and swam the last third of the way down. In another trial, out of three at the top one swam down 31 cm. without touching the sides of the jar. From this it seems that change of light intensity starts, and gravity, also a stimulus, directs the downward course.

While there is no doubt that the up-swimming of Gonionemus is directed by gravity, as stated by Yerkes [(5) p. 281], nevertheless light seems to be a more important factor than he says. Indeed I may say it is a necessary condition as may be seen from what follows. That it is not directive Yerkes [(5) p. 281] has shown by his experiment of bottom illumination. The medusae move up to the surface and turn over normally. But casual observation of the upper surface of the water shows that it is sufficiently illuminated from the bottom to allow the medusae to come to the top. So I substituted lateral illumination through an opening near the bottom of the aquarium. The aquarium was otherwise darkened and reflection reduced as much as possible by filtering the water. Now the medusae swam near the bottom, 8 cm. being the greatest height reached. As a check, bottom illumination was then used and immediately one of the animals swam to the surface and one came near it. Three other experiments were made and the most striking

5. American Jour. Physiol., 1903. Vol. IX.

case was that of one medusa swimming through the light area 14 times in 72 seconds without reaching top or bottom. When the aquarium was so dark that I could not see the medusae, sudden illumination showed that they had attached by their tentacles to the side of aquarium. This reaction has been often observed in connection with other violent stimuli and will be reported at another time. Thus the presence of light seems necessary for the regular up-swimming activity of Gonionemus and gravity may direct it.

In regard to the part light plays in the surface reaction Yerkes [(3) page 459] says, "although light seems to be one of the important conditions for this reaction, it may occur in the absence of light." From the experiment just cited I would conclude that the chief importance of light is in bringing Gonionemus to the surface. Morse [(3) p. 451] says "The cause for reaction is not evident." Later [(4) p. 686] he explains the "inversion" by assuming that the bell is thrust above the surface unevenly. Yerkes [(5) p. 255] has given a similar explanation. Gravity, no doubt, causes the inversion, not as a stimulus but because the apex of the bell is heavier.

Now as the inversion at the surface is preceded by inhibition of contraction the question arises as to the cause of this inhibition. Yerkes (5, p. 281) and Morse (3, pp. 450, 451) have observed that medusae do not turn (invert) when made to swim up against a heavier substance than air, such as board, a glass plate, or a layer of olive oil, but they continue to swim against these layers until exhausted. From these results I believe that contact of the apex of the bell with air normally causes cessation of movement (inhibition). This could be proved by holding a layer of imprisoned air some distance below the surface of the water (7). Light is probably not the cause [Morse (3) p. 451] and therefore no further discussion is warranted here.

SUMMARY.

1. Change of light intensity, not light per se, is a normal stimulus for reactions of Gonionemus.

2. The medusae do not usually direct their movements to favorable locations but continue to make random movements until they come into an optimum environment.

3. Relative intensity of light and not ray direction determines the place of rest.

4. Intense light may direct the medusae causing them to turn away from its source. Ordinary light is important for the up-swimming activity, though not directive, this being due to gravity.

5. Contact of the bell with air may cause the inhibition of movement and relaxation allowing inversion of the bell by gravity.

Detroit, Mich., April 1909.

3. Jour. of Comp. Neurol. Psychol., 1906, Vol. XVI.
4. American Nat., 1907, Vol. XLI.
5. American Jour. Physiol., 1903, Vol. IX.
7. This has since been verified, but another explanation will be given in another place. (Biol. Bul., 1909, Vol. XVII, p. 354.)

PRESERVATION OF CATS FOR DISSECTION.

JESSE J. MYERS.

In 1904 it became necessary for us to provide some method whereby we might preserve cats for a number of weeks, while they were being dissected. After five years of experiments, many of which were unsatisfactory, we have arrived at certain methods and conclusions which may be of interest to those who may care to preserve mammals for future dissection.

The method we use at present is as follows: The animal is killed with chloroform. It is then placed on a dissecting board, and a small incision is made through the skin on the inner side of the right thigh, exposing the femoral vein. A small glass canula is inserted in the vein, with its point directed toward the heart. The vein is then ligated below the canula to prevent a flow through its other opening, and the canula is now connected to a siphon that leads from a reservoir about five feet above the level of the cat. In this reservoir has been placed about thirteen hundred c. c. of the following embalming fluid:

Carbolic acid crystals, 8 grams.
Glycerine, 82 grams.
Sodium arsenate, 137 grams.
Formalin 4 per cent, 1000 cc.

The animal is left in this position from two to three hours, or at least until it ceases to receive more of the embalming fluid. A cat of average size will take about one thousand c. c. of the fluid. The pressure has been sufficient to rupture some of the smallest blood vessels of the abdomen and so the abdominal cavity will be enormously distended with the embalming fluid. To insure perfect injection of the head, neck and extremities, it may be well to occasionally give these a slight massage. This we scarcely ever do, however. If there has been sufficient injection of the head and neck region it is usually indicated by a seepage from the nostrils, caused by the rupture of small blood vessels.

The animal should now be laid away for a few days before dissecting in order to permit the fluid to penetrate. When the abdominal cavity is opened the embalming fluid can be removed with a sponge, and in a very short time the tissues will lose their excessive moisture. At this point in the dissection we are accustomed to inject the arterial system, both backward and forward through the abdominal aorta at a point a little anterior to the renal arteries. Plaster of Paris, mixed with water and a coloring agent, makes a very good injection mass for all ordinary dissection work, and seems to be more convenient than the starch injection mass most commonly used.

With the exception of possible attacks of moulds the animal may now be kept for weeks. At the close of each laboratory period we spray the interior and uncovered parts of the cat with a weak solution of carbolic acid, using for this purpose an injection syringe having a fine nozzle. The student is then requested to wipe the cat as dry as possible, using a sponge. The more thoroughly this is done the better will be the later condition of the animal. The cat is then thoroughly wrapped with its own skin, which has been only partially removed, and thus laid away until when next needed.

Our five years of experience have taught us the following facts:

1. Cats have been kept in perfect state of preservation for ten weeks, being exposed to the outdoor temperature of late winter and early spring. We are now experimenting with a view of determining how far into the summer specimens will resist decay.

2. We have found nothing better than the skin, with which to wrap the bodies to prevent moulding and the drying of the tissues.

3. Cats that have not been bled seem to be preserved just as well as those that have had the blood removed previous to enbalming.

4. We inject through the fermoral vein instead of the femoral artery, primarily because it is much easier to insert the canula and also because it sends the embalming fluid in the same direction as is taken by the blood.

5. It has been demonstrated that the viscera need not be removed for weeks.

6. We have found that the use of an injecting syringe for introducing the embalming fluid has brought disastrous results. It means too limited time at too great a pressure. Less pressure continued over a period of from one to three hours insures far better penetration.

East Lansing, April 1, 1909.

KEY TO THE GENERA OF GASTROPODA OF MICHIGAN.

H. Burrington Baker.

This key is a purely artificial one and is based mainly on the shape of the shells. Characters varying with age are excluded, in so far as possible, but it was found impossible to make a key that would positively identify young shells; these, however, the student will soon learn to recognize. Technical terms have been used as little as possible; those used are explained in the glossary.

The key begins by dividing the gastropods into two groups; those without shells and those with them. The latter are subdivided into six divisions: heliciform, planorbiform, lymnaeiform, pupiform, turretiform, and patelliform shells. These divisions are made on the shape of the shell and will be understood upon examining the illustrations. In cases where a shell might be included under more than one head, this has been done.

The illustrations are printed through the generosity of Mr. Bryant Walker, who provided the plates. An example of each genus is given, and the number after each indicates the number of diameters the drawing is magnified. In preparing this key, use has been made of Mr. Bryant Walker's[1] and Mr. F. C. Baker's[2] papers. The student is refered to them for settling doubtful points.

Animal with no visible shell, i. e. slugs 1
Animal with a visible shell, i. e. snails 3

1. Animal with internal shell; mantle covering only anterior part of slug ..... *Agriolimax*
   Animal without internal shell; mantle covering all of animal 2

A. campestris (Say)[3] ×1.

2. Animal large; adults 10 c. m. long, spotted. *Philomycus.*

P. carolinensis (Bosc) ×1.

   Animals small; adults 2.5 c. m. long, unspotted ..... *Pallifera.*

P. hemphilli (W. G. Binney) ×1.

3. Shell heliciform, broader than high 4
   Shell planorbiform, spire not above last whorl 18
   Shell lymnaeiform, higher than broad, with an acute apex 20
   Shell pupiform, higher than broad, with a rounded apex, aperture transverse 32
   Shell turretiform, conical, with almost straight sides 40
   Shell patelliform, with no coiled spire 42
4. Shell operculated, with continuous peristome, small, 7 mm. high .. 5
   Shell not operculated, peristome not continuous 6

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[1] Geological Surv. of Mich., Ann. Rept. 1905.
[2] Chicago Acad. of Sci., Bull. III of Nat. Hist. Survey.
[3] The names of authorities are all included in parentheses whether that authority used the generic name or not.

5. Shell, subdiscoidal, aperture circular or nearly so.....*Valvata.*

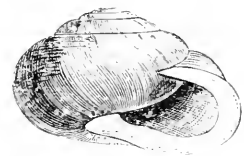
V. tricarinata. (Say) ×2.

Shell subglobose, aperture not circular.....*Somatogyrus.*

S. subglobosus (Say) ×3.

6. Shell with broadly reflected peristome..... 7
Peristome not reflected, edge of aperture sharp..... 9

7. Shell large and dull, more than 5 mm. in diameter.....*Polygyra.*
Shell small and shining, less than 3 mm. in diameter..... 8

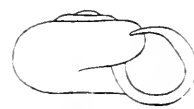


P. albolabris (Say) ×1.

8. Lamellae on parietal wall and base of last whorl.....*Strobilops.*

S. labyrinthica (Say) ×10.

No lamellae or teeth on inside of last whorl.....*Vallonia.*



V. pulchella (Mull.) ×10.

9. Shell dull, coarsely ribbed.....*Pyramidula.*
Shell shining, usually smooth; a few small northern species minutely ribbed..... 10

P. alternata (Say) ×1.

10. Shell smooth and shining but not vitreous; umbilicus very wide and deep.....*Circinaria.*
Shell smooth and shining and vitreous, umbilicus narrower..... 11

C. concava (Say) ×1.

11. Shells with diameter greater than 11 mm., with one exception that has 7 to 8 whorls and a diameter of 8 mm..... 12
Shells with diameter less than 6 mm., with one exception that has 5 to 6 whorls and a diameter of 7½ mm..... 13
(The shell mentioned as the first exception in the above is *Gastrodonta demissa*, and may be further distinguished from the other, *Zonitoides nitida*, by the presence of two lamellae on the peristome of the former. The latter may be told from all the others of No. 11 in that the animal is jet black and the shell is transparent, so that the living shell appears black).

12. Shell subdiscoidal, with very little spire, diameter less than 15 mm.....*Omphalina.*

O. fuliginosa (Griff.) ×1.

Shell subdiscoidal if less than 11½ mm. in diameter; almost as high as broad if 15 mm..*Gastrodonta.*

G. ligera (Say) ×1.5.

13. Parietal wall and base of last whorl, each with two entering lamellae, shell obliquely and coarsely striated..... 8
No teeth or lamellae with one exception, *Vitrea multidentata*, which has two or more rows of minute teeth, not lamellae, and is not striated..... 14

14. Shell subglobose, altitude almost as great as diameter, aperture basal.....*Euconulus.*
Shell subdiscoidal, altitude much smaller than diameter; aperture almost lateral..... 15

E. fulvus (Mull.) ×5.

15. Shell minute, diameter 1½ mm., with four whorls, reddish horn color.....*Punctum.*
Shell with diameter greater than 2½ mm., with two exceptions both of which are pure white and have but three whorls..... 16

P. pygmaeum (Drap.) ×15

16. Last whorl considerably wider than all of the rest combined.....*Vitrina.*
Last whorl considerably narrower than all of the rest combined..... 17

V. limpida (Gould) ×1+.

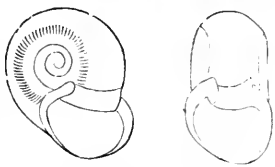
17. Shell very transparent, last whorl rapidly increasing in diameter towards the aperture, no spiral sculpture.....*Vitrea.*

V. indentata (Say) ×2.

Shell clouded, whorls increasing gradually in size, shell with microscopic spiral striae...*Zonitoides.*

Z. nitida (Mull.) ×2.

18. Aperture without teeth, diameter greater than 10 mm., or shell sinistral.....*Planorbis.*
Aperture with teeth, diameter less than 8 mm., shell dextral..... 19



P. trivolvis (Say) ×1.

19. Aperture with slight inner callus; diameter greater than 6 mm., color brown.....*Segmentina.*

S. armigera (Say) ×1.

Aperture with lamellae that run around the inside of all of the whorls, and which are visible from the outside; diameter less than 4 mm., color greenish horn.....*Helicodiscus.*

H. parallelus (Say) ×5.

20. Shells sinistral..... 21
Shells dextral..... 22

21. Shell very long and narrow, aperture attenuated above, columellar lip simple, mantle with simple edge.....*Aplexa.*

A. hypnorum (L.) ×1

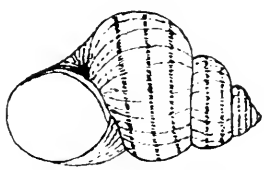
Shell and aperture nearly oval, columella provided with callus which is spread over last whorl, mantle fringed with finger-like filaments..*Physa.*

P. gyrina (Say) ×1.

22. With operculum, peristome continuous or continued by a callus so that the operculum entirely closes the shell, shell heavy although often small..... 23
Without operculum, peristome not continuous, shell thin and fragile..... 29

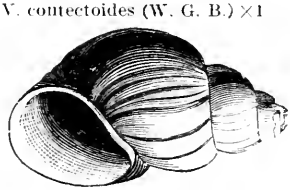
23. Shell large, altitude more than 18 mm..... 24
Shell small, altitude not more than 11 mm..... 25

24. Shell usually banded, aperture and operculum almost circular.....*Viviparu.*



V. contectoides (W. G. B.) ×1

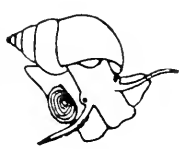
Shell not banded, aperture narrow-oval, with upper side straight.....*Campeloma.*



C. decisum (Say) ×1.

25. Shell subglobose, aperture two-thirds as high as entire shell 5
Shell conical, aperture not one-half as high as entire shell..... 26

26. Altitude of shell about 10 mm.; operculum almost circular with a blunt projection pointing upwards.....*Bythinia.*
Altitude of shell not over 7 mm.; operculum without such a projection..... 27



B. tentaculata (L.) ×1.5.

27. Shell elongated peristome reflected.....*Pomatiopsis.*
Shell conical, peristome not reflected..... 28

P. lapidaria (Say) ×3

28. Shell umbilicate, outer lip of aperture thin.....*Amnicola.*

A. limosa (Say) ×2

Shell with almost no umbilicus, outer lip of aperture thickened.....*Paludestrina.*

P. nickliniana (Lea) ×2

29. Land snails, shell thin, translucent, fragile, tentacles invertible, with eyes at their tips..... 30
Aquatic snails, shell more opaque and heavier, tentacles not invertible, with eyes at bases..*Lymnaea.*

L. palustris (Müll.) ×1

30. Shell distinctly ribbed.....*Acanthinula.*
Shell not ribbed..... 31

A. harpa (Say) ×6.

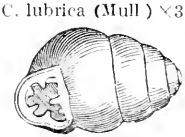
31. Aperture usually more than half as high as entire shell, which is three whorled.....*Succinea.*

S. ovalis (Say) ×1.

Aperture about one-third as high as entire shell, which has 5 to 6 whorls.....*Cochlicopa.*

C. lubrica (Müll.) ×3¾.

32. Aperture with outer lip regularly rounded.... 33
Aperture with outer lip more or less contracted above the middle, usually strongly indented at this place.....*Vertigo.*



V. ovata (Say) ×11

33. Aperture edentate..... 34
Aperture dentate..... 38
34. Last two whorls with prominent thin ribs, first two without ribs.. 30
Shell not more than distinctly striate..... 35

35. Shell minute, altitude not over 2 mm....*Sphyradium.*
Shell larger, altitude not less than 4 mm.... 36

S. edentulum (Drap.) ×11.6.

36. Aperture almost twice as high as wide, peristome thickened.... 31
Aperture either almost circular or wider than high, peristome reflected..... 37

37. Aperture rounded-oval and almost circular, shell white..... *Pupoides.*

P. marginatus (Say) ×4.

Aperture wider than high, shell dark chestnut..... *Pupilla.*

P. muscorum (L.) ×5.

38. No teeth on columellar wall..... 39
One or more teeth on columellar wall..... *Bifidaria.*

B. tappaniana (C. B. Adams) ×9

39. Shell minute, altitude about 2 mm., color white..... *Carychium.*
Shell larger, altitude about 4 mm., color dark chestnut..... 37

C. exiguum (Say) ×8

40. Shell small, altitude not over 7 mm..... 27
Shell large, altitude over 12 mm..... 41

41. Aperture produced into a canal in front, whorls flattened..... *Pleurocera.*

P. elevatum (Say) ×1

Aperture merely angulated in front with no canal, whorls more convex..... *Goniobasis.*

G. livescens (Menke) ×1.

42. Shell with cap at end, nucleus almost central..... *Gundlachia.*

G. stimpsoniana (Smith) ×5.

Shell simple conical, nucleus at left of center..... *Ancylus.*

A. kirklandi (Walker) ×5

Glossary:

Aperture—the opening through which the animal extrudes itself.
Callus—thickening of the shell, usually around aperture.
Columella—twisted central axis of shell.
Mantle—membrane surrounding respiratory cavity.
Operculum—calcareous "door" to the aperture, borne on the animal's foot.
Parietal wall—wall of aperture nearest central axis of shell.
Peristome—edge of aperture.
Subdiscoidal—flattened, spire rising but little over last whorl.
Umbilicus—cavity in base of shell.
Vitreous—glassy, very clear and transparent.

THE INFLUENCE OF DARWINISM UPON PSYCHOLOGY.

N. A. Harvey.

The widest generalization of the human mind is the doctrine of evolution Everything from a monad to man falls within its reach. Sand grains and star clusters furnish evidence of its truth. Nothing in the universe escapes its all comprehending boundaries.

Psychology was studied before Spencer wrote or Darwin dreamed. From Aristotle to Locke and Hume, thoughtful men had reflected upon the activities of their own minds. It must be remembered that Spencer was the author of the doctrine of Evolution, while Darwin furnished the evidence that rendered its truth demonstrable. Spencer wrote his greatest book, the Principles of Psychology, and unquestionably the greatest book in the history of the subject, in 1855, four years before the publication of the Origin of Species. Darwin himself presented to psychology his masterly volume upon the Expression of the Emotions, still our greatest book upon that phase of the subject. Romanes contributed to its advancement, while to Huxley, the science is also a debtor.

With such an impetus from the great Prophets and Lawgivers of Evolution, it was to be expected that, when Evolution had become an article of faith with all thinking men, Psychology would be one of the first branches of science to profit by its supremacy. Such has not been the case. Any discussion of the topic announced at the beginning of this paper must take on something of the form of an explanation why psychology has profited so little by the predominance of evolutionary thought. Biology and subjects with biological affiliations were the focus of the Darwinian illumination, but psychology is almost the last department of human knowledge to feel its full effect. Botany and zoology have been transformed by it. Chemistry and physics have felt its beneficent influence. New departments of knowledge have been born into the hierarchy of science through its quickening power. But psychology has, until recently, placidly refused to respond to its magical touch.

The reasons for this delay are not far to seek. A modification of psychological conceptions touches more intimately than does any other branch of knowledge, the religious faith and the personal pride of men. Even Lyell, to whom Darwin attributed a greater influence upon his own thought and labors than to any other person, could not go with Darwin into his speculations concerning the origin of man. Wallace, the co-discoverer of Darwinism, refused to believe in the efficacy of Evolution to account for man's spiritual nature. And now, while nearly every intelligent person acknowledges the evolutionary and natural origin of man, even to his psychical endowment, the flag still flies over the solitary stronghold that defends the supernatural character and destiny of the human personality.

Hence it is that any evolutionary explanation of man's psychical nature which seems to weaken the bulwarks of religious dogma is fought with bitterness and acrimonious zeal. The armor piercing projectile of "materialism" is hurled against it. Intuitional evidence is asserted to be of more

weight than scientific demonstration, and personal prejudice produces unshakable conviction.

Besides the fear that an evolutionary psychology will demolish the doctrine of a supernatural soul, psychology has until now failed to escape from the domination of metaphysical philosophers. It is still treated as a department of philosophy rather than a natural science. Metaphysicians are practically untouched by an evolutionary philosophy. The metaphysical gods that are set up and worshiped antedate the evolutionary era, and the founder of evolution himself is drummed out of the philosophical camp. As a result, we find psychology scarcely as yet escaped from the philosophical verbiage which for centuries kept it in a condition approximating perilously near to asphyxia, for, in the words of Saleeby, "the principal bequest that metaphysicians have left to psychology is a heritage of concatenated words." The followers of Kant and Hegel and Plato have, up to the present, written the psychologies and dictated the officers of the psychological hierarchy. The disciples of Darwin and Spencer have, likewise up to the present, neither written the psychologies nor devoted themselves to the development of the subject; instead, as it has been promulgated by metaphysical philosophers, they have experienced a heartfelt contempt for its conclusions.

Instead of following the lead of Darwin and Spencer, and basing psychology upon the principle which is the essential element in Darwinism, that every mental characteristic is either now, or has been in the recent past, advantageous to the individual or to the species, psychologists generally have failed to see its application and have plodded along as if Darwin had never lived and laid out new laws for the biological kingdom. They have failed to see the significance of sleep as a self preserving character; of pain as a beneficent advantage to the race and to the individual; of spontaneous attention as an essential means of adjustment; of the necessary classification of feelings into self-preserving, community-preserving and race-perpetuating, with their expression intrepreted as either a useful action or an accidental circumstance. They have made of consciousness an all-pervading condition of mental life, instead of an accidental concomitant, or an epiphenomenon, as Huxley called it.

Notwithstanding this delay in appropriating to itself some of the life-giving essence of evolution, psychology has experienced some of the transforming influence that has touched other sciences. Especially is this true in the latest years. It is now possible to say, as Mr. Buchner does in a recent number of the Psychological Bulletin, that "the past year's work is characterized by a number of contributions of widely divergent range, bringing the general hypothesis of Evolution closer to the problems of psychology and taking the vantage points of the science over into the present needs of the theory." There is evidence that henceforward, evolutionary conceptions will exercise greater influence in psychology than they have done in the past. It is well, even now, to gather up the evolutionary ideas that have found a place in psychology as a view point for a prospect into the future.

Evolutionary conceptions have taught us to interpret mental habits, tastes, preferences and feelings, as well as emotional expression by means of the ancestral life that human beings and pre-human progenitors have lived. Instinctive fears, ideas that have been called intuitive, successive appearances of well-marked stages in mental life that have their counterparts in physical growth, each with its own series of tastes, activities and aspirations, can be interpreted only in terms that evolution has given us.

The human being of today has been molded by the stress and strain of half a million years of ancestry, and no longer appeals to us as a creature—in the terms of pre-evolutionary psychology—fresh from the hands of God. Instead of being a new creation, the little child is the oldest of all men, combining in his potencies the largest amount of organized experience. Such a conception was utterly impossible to a pre-evolutionary psychologist, and even today, many psychologists tarred with the metaphysical stick, although honestly believing themselves evolutionists, are unable to attain it.

Related to the conception just mentioned, is the new attitude toward moral and mental delinquents. No longer do we regard criminals as children of the devil, and an idiot as one afflicted of God, but we see in them the result of an atavistic tendency which leads man back into the seas and swamps of a paleo-psychic age. Children are mentally and morally irresponsible, but this expression is itself an archaism from the metaphysical psychology of the ante-diluvian period. Irresponsibility is as natural and as inevitable to children as responsibility is to a grown-up. Children need to grow, and it is the duty of a philosopher and a philanthropist to furnish them suitable conditions for growth. Here we find in evolutionary psychology a justification for education—universal, thorough, all-pervading education—that it was impossible to discover in the psychology of the past. It was impossible to conceive of a science of education in terms of the old psychology. For education, the new psychology derived from Evolution, is full of promise and hope of fulfillment. A science of education is possible since Darwin wrote.

Employing the Darwinian principle of Natural Selection, we have in evolutionary psychology an explanation of the mental differences between men and women. Every mental characteristic is now or has been in the recent past, an advantage to the individual, to the community, or to the race which exhibits it. As a result, we shall find that the mental processes of men and women differ in exactly the degree that the physical and sociological functions differed in the development of the human race. No possibility of attaining such a conception presented itself to the metaphysical psychologist who saw in the human body only the instrument of a metaphysical entity which he called mind.

Evolution has compelled psychology to become genetic and functional instead of descriptive and (most inappropriate of all adjectives) rational. There is scarcely a more irrational thing known than rational psychology. Psychological facts find their explanation in antecedent physiological conditions. Until this principle has been adopted as the foundation for all psychical research, no progress is possible. Whether we regard the psychical as the product and the result of the physical, as a function of the nervous organism, or whether with Wundt we consider the doctrine of psycho-physical parallelism as an all-sufficient statement of the relation existing between mind and body, progress in psychology is possible only by assuming that mind and body constitute an inseparable unity, subject to the same evolutionary laws, and originating in the same antecedent condition. The real nature of the mind, the thing in itself, does not enter into any scientific conception of psychology, and may very properly be left out of consideration until more is known about the real nature of mental processes and their relation to each other.

Evolution has produced such an effect upon psychology that at present, child psychology—mental ontogeny—constitutes its most promising depart-

ment. This field, totally neglected by all psychologists from the time of Aristotle until the time of Darwin, is now seen to be the one in which can best be studied the phenomena that most urgently demand explanation. The changes of personality; the sudden growth of instincts; the operations of feelings and their function in mental life, all these when studied in children by the aid of evolutionary principles, have thrown such a flood of light upon the nature of mental processes as to render obsolete and useless all works upon psychology that are based upon the conceptions of a pre-evolutionary age. It is a field that would never have been cultivated under the paralyzing influence of the doctrine that mind is a metaphysical entity using the body merely as an instrument, but dependent upon it only as a means of expression and for producing motion in material things.

Evolution has shown us, also, the kinship existing between men and other animals in the psychological world. Unfortunately, psychologists have generally not been acquainted with animal life and structures sufficiently to study the subject with advantage, and zoologists have been too busy, or too little informed about psychological processes to make such a study profitable. Hence we find in this field of mental phylogeny the most divergent and contradictory opinions maintained in places where we have the right to expect the most profitable studies to be made, and the greatest unity of method and conclusion to prevail. The doctrine of evolution, here, must be our guide out of the labyrinth.

From this time forward it seems probable that psychologists will recognize that natural selection, in its application to human development, at least, has been a selection by means of characteristics that belong, not to the physical alone, nor to the psychical, but to the total complex of the psychophysical organism. There have been not two movements in evolution, a physical and a psychical, but the two series have been carried forward together, constituting a single genetic movement. This conception was impossible so long as it was believed that the mind and the body were two different entities instead of being a single complex. It seems evident, now, that the body has developed in consequence of the selection by psychic processes of variations which without psychical selection would have been destroyed or overlooked. The law of functional selection is necessary for any satisfactory understanding of the method by which Darwinism is applied to the human being at least, and functional selection depends upon psychical processes.

Equally necessary is it to take into account the variations of the body in any attempt to explain the origin and real significance of mental processes that have been the subject of study from the time of Aristotle downward. It would have been impossible for the mind to develop by the selection of utilities for which the body presented no variations. Mind in man has become what it is in consequence of the variations that the body has exhibited.

It seems that the dynamogenetic law has been thoroughly established in psychology. But the law of dynamogenesis itself is an application of the law of natural selection. Every conscious voluntary act is an example of the Darwinian principle of natural selection and no act of consciousness can produce a voluntary act unless the variation that has been psychically selected has been previously established.

Without any question, the prevailing psychology of today is German psychology. Until recently, psychology was essentially an English science; but Fechner, Weber and Wundt have directed it into such a path that it

has become essentially German. The German method is characterized by a slow and laborious accumulation of data, and is deficient in the very element that the doctrine of evolution supplies. The German method has freed psychology completely from the hypothesis of a metaphysical entity called mind, and has enabled it to reach the point where it has been called in derision, a psychology without a soul. This is the condition that every subject of knowledge must reach before it can be called a science. It must be a science of phenomena, and not a science of ultimate causes. German psychology has regarded physiological processes as a means of studying the psychical, and has introduced experiment as a primary means of psychological research. The demonstration of Weber's law has rendered forever impossible the continuance of the former conception of mind as a postulate for psychical study.

But the German psychology is deficient in a great synthesizing principle that shall guide discovery and summate all progress. All psychical facts are valuable, but not all are of equal importance. Sometimes, also, I fear that we are too busy in trying to find out what the Germans are doing to accomplish all that we ought to do ourselves.

The greatest need in psychology today is the formulation of a synthesizing principle, based upon the doctrine of evolution, and including the facts discovered by German methods, which shall enter every field of psychical activity and shall bring all departments of research under its dominion. We need for psychology a restatement of evolution in psychological terms; and I predict that it will not be many years before a new Darwin will arise in psychology and that this Schoolmaster's Club will listen to a continuation of this paper in newer terms than it is possible now to employ.

Ypsilanti, April 2, 1909.

COMPLETE LIST OF PAPERS AND ADDRESSES PRESENTED AT THE FIFTEENTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE.

1. Address of the President, The Beginnings of Life from the View Point of a Bacteriologist, Dr. C. E. Marshall.
2. Theories of Animal Coloration, especially Warning Coloration, Prof. Jacob Reighard.
3. The Theory of Orthogenesis, Dr. Alexander Ruthven.
4. American Palaeontology and Neo-Lamarckism, Prof. E. C. Case.
5. The Mutation Theory from the Botanical View Point, Dr. Henri de Leng Hus.
6. Public Address by Dr. W. B. Scott, Blair Professor of Geology and Palaeontology, Princeton University (Under the auspices of the Research Club of the University of Michigan).
7. Addresses by Professor C. B. Davenport, Director of the Station for Experimental Evolution of the Carnegie Institution, Cold Spring Harbor, N. Y., and others on the subject of Heredity.

The Effect of the Darwin Doctrines:

8. —On Biology, Prof. C. B. Davenport.
9. —On Psychology, Prof. N. A. Harvey.
10. —On Education, Pres. E. G. Lancaster.
11. —On Religion, Rev. Carl S. Patton.
12. Some Reminiscences of the Attitude of Harvard Professors toward Darwin's Work, W. J. Beal.
13. Darwin's Influence on Plant Breeding, H. J. Eustace.
14. Darwin's Influence on Animal Breeding, A. C. Anderson.
15. Further Experimental Work on the Interaction of Plant Roots, J. B. Dandeno.
16. Advanced Methods in Milk Analysis, W. E. Robison.
17. A Discussion of the Value of Raw Rock Phosphate for Fertilizing Purposes, A. J. Patten.
18. Osmotic Theories, with Special Reference to Van't Hoff's Law, J. B. Dandeno.
19. Investigation on Bordeaux Mixture, J. B. Dandeno.
20. The Rapid Extension of Weeds in Michigan, W. J. Beal.
21. Origin of the Flora of Local Peat Bogs, Geo. P. Burns.
22. The Effect of Longitudinal Compression upon the Production of Mechanical Tissue in Stems, L. H. Pennington.
23. The Plasticity of Some of the Compositae around Ann Arbor, S. Alexander.
24. The Phytogeographical Relations of the Mount Ktaadn Flora, L. H. Harvey.
25. Notes on Plant Pathology, J. B. Pollock.
26. The Carbon Nutrition of a Fungus, Rose M. Taylor and J. B. Pollock.
27. The Culture of Fern Prothallia, Elizabeth D. Wuist.
28. Unreported Michigan Fungi for 1908, C. H. Kauffman.
29. Methods of Sterilizing Seeds, Richard de Zereuw.

30. Growth of Water Cultures in Various Solutions, N. W. Scherer.
31. Variations in Leaves and Flowers, Henri de Leng Hus.
32. Variations in the Dimensions of the Tracheids of *Picea excelsa*, S. M. Hamilton and W. H. Ramson.
33. The comparison of the Loess Deposits of Europe and America, Frank Leverett.
34. The story of Niagara told in Photographs (Illustrated), Frank B. Taylor.
35. An Aegerite-Oligoclase Aplite from the Lake Superior Region, Alfred C. Lane.
36. The Differentiation toward the Most Fusible Mineral (Augite) in Non-hydrous Magmas, Alfred C. Lane.
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38. The Physiography of an Ancient Delta Region in Texas (Illustrated), E. C. Case.
39. Some New Occurrences in Iodyrite, C. W. Cook.
40. The Use of Crystallography in the Identification of Commercial Chemical Compounds, E. H. Kraus.
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42. The Iron Ores of Spring Valley, Wisconsin; R. C. Allen.
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45. The Flint Water Supply, Alfred C. Lane and F. Harlan Bretz.
46. Stadia of the Wisconsin Glaciation in North America (Illustrated), Frank Leverett.
47. Iodyrite from Tonapah, Nevada and Broken Hill, New South Wales; E. H. Kraus and C. W. Cook. (Science Vol. XXVII, 1909, p. 210.)
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49. The Standardization of Contact Insecticides, H. C. Hamilton.
50. The History of the Sausage, Floyd W. Robison.
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62. Leishmaniasis (with lantern demonstration), F. G. Novy.
63. Notes on Michigan Reptiles and Amphibians, A. G. Ruthven.
64. Notes on the Crayfish of Michigan, A. S. Pearse.
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68. Effects of Centrifugal Force upon the Embryonic Development of some Chrysomelid Beetles, R. W. Hegner.
69. The Germ Cell Determinants in Beetles, R. W. Hegner.
70. Some Light Responses in the Jelly-fish, Gonionemus, Louis Murbach.
71. Reaction of Amphibians to Light, A. S. Pearse. (Abstract, Science N. S. Vol. 29, No. 741, p. 431-432.)
72. Method of preserving Material for Vertebrate Dissection, J. J. Myers.
73. Effects of pressure upon the Embryonic Development of Some Chrysomelid Beetles, R. W. Hegner.
74. The Distribution of the *Unionidae* of Alabama, Bryant Walker.
75. Notes on a Double Snail (*Campeloma*), Hansford MacCurdy.
76. Notes on the Skeleton of *Chamaelcon cristatus*, Stutchb., E. C. Case.
77. Locality Memory in the Woodchuck, Jacob Reighard.
78. Key to Genera of Michigan Gasteropods, H. B. Baker.
79. Pearl Organs: A Secondary Sexual Character Showing Diversity not Easily Explained through Use, N. H. Stewart.

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Georg-Augusts Universitaet, Goettingen, Germany.
Georgia University Library, Athens, Georgia.
Glasgow Geological Society, Glasgow, Scotland.
Glasgow School Board, Glasgow, Scotland.
Glasgow University Library, Glasgow, Scotland.
Government Botanist, Melbourne, Victoria, Australia.
Grand Rapids Public Library, Grand Rapids, Michigan.
Grossherz Bad. Albert-Ludwigs Universitaet, Bibliothek, Freiburg, Germany.
Grossherz Hessische Ludwig-Universitaet, Bibliothek, Giessen, Hessen, Germany.
Grossherz Ruprecht-Karls Universitaet, Heidelberg, Germany.
Grossherz Saechsische Gesamt Universitaet, Bibliothek, Jena, Germany.
Gulf Biological Station, Baton Rouge, La.
Hackley Public Library, Muskegon, Michigan.
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Harvard Museum of Comparative Zoologie, Cambridge, Mass.
Harvard University, Gray Herbarium, Cambridge, Mass.
Havana University Library, Havana, Cuba.
Hillsdale College Library, Hillsdale, Michigan.
Historical and Scientific Society, Wilmington, N. C.
Hrvatsko Prirodoslovno Drustvo, Agram, Croatia, Austria-Hungary.
Hull Literary and Philosophical Society, Hull, England.
Idaho University Library, Moscow, Idaho.
Illinois Geological Survey, Urbana, Ill.
Illinois State Laboratory of Natural History, Urbana, Ill.
Illinois State Museum of Natural History, Springfield, Ill.
Illinois University Library, University Station, Urbana, Ill.
Imperial Charkovskii Universitet, Bibliothek, Charkow, Russia.
Imperial Moskovskij Universitet, Moskow, Russia.
Imperial Varsavskij Universitet, Bibliothek, Warsaw, Russia.
Imperial Institute of the United Kingdom, London, England.
Imperial Iurjevskij Universitet Bibliothek, Dorpat, Russia.
Imperial Moskofskoie Obshchestvo Iestestvo-Ispytatelei, Moskow, Russia.
Imperial Moskofskii Universitet, Moscow, Russia.

Imperial Sankt-Peterburgskoie Mineralogicheskoie Obshchestvo, St. Petersburg, Russia.
Imperial University of Tokyo, Library, Tokyo, Japan.
Indiana Academy of Science, Indianapolis, Ind.
Indiana Geological Survey, Indianapolis, Ind.
Indiana University Library, Bloomington, Ind.
Inspectorate General of Customs, Statistical Department, Shanghai, China.
Institute of France, Paris, France.
Institute des Mines, St. Petersburg, Russia.
Institute Luxembourgeois, Section des Sciences Naturelles, Luxemburg, France.
Institute of Jamaica, Kingston, Jamaica.
Institute Royale de la Suéde, Stockholm, Sweden.
Istituto Historico, Geographico y Ethynographico, Rio de Janeiro, Brazil.
Institution of Civil Engineers, Great George St., London, England.
Iowa Academy of Science, Des Moines, Iowa.
Iowa Geological Survey, Des Moines, Iowa.
Iowa University Library, Iowa City, Iowa.
Iron Mountain Carnegie Library, Iron Mountain, Michigan.
Istituto Scientifico della R. Universita, Rome, Italy.
Jackson Public Library, Jackson, Michigan.
Jagellonische Universitaet, Bibliothek, Karkau, Austria-Hungary.
Jenaische Zeitschrift fuer Medicin u. Naturwissenschaften, Jena, Germany.
The John Crerar Library, Chicago, Ill.
Johns Hopkins Press, Baltimore, Md.
K. Bayerische Botanische Gesellschaft, Regensberg, Germany.
K. Boehmische Gesellschaft der Wissenschaft, Prag, Austria-Hungary.
K. K. Deutsche Karl-Ferdinand Universitaet, Bibliothek, Prag, Austria-Hungary.
K. K. Geographische Gesellschaft, Wien, Austria-Hungary.
K. K. Geologische Reichsanstalt, Wien, Austria-Hungary.
K. Leopoldinisch-Caroloninische Deutsche Akademie der Naturforschen, Halle-an-der-Saale, Germany.
K. K. Leopold-Franzens Universitaet, Bibliothek, Innsbruck, Tirol, Austria.
K. Magyar Természettudományi Társulat, Austria-Hungary.
K. K. Universitaet, Bibliothek, Wien, Austria-Hungary.
K. K. Zoologisch-Botanische Gesellschaft, 3 Mechelgasse, Wien, Austria-Hungary.
K. Zoologische Genootschap "Natura Artis Magistra", Amsterdam, Netherland.
Kais Universitaet Bibliothek, Kasan, Russia.
Kaiser-Wilhelms-Universitaet, Bibliothek, Strassburg, Germany.
Kaiserliche Universitaet, Bibliothek, St. Petersburg, Russia.
Kansas Academy of Science, Capitol Bldg., Topeka, Kansas.
Kansas State Historical Society and Department of Archives, Topeka, Kansas.
Kansas University, Geological Survey, Lawrence, Kansas.
Kantonale Universitaet, Bibliothek, Bern, Switzerland.
Kentucky State College, Agricultural Experiment Station, Lexington, Ky.
Kjbenhavns Universitet Bibliothek, Kopenhagen, Denmark.
Kongl. Albertus Universitaet, Bibliothek, Koenigsberg, Prussia, Germany.

Kongl. Alexanders Universitetet I Finland, Bibliothek, Helsingfors, Finland.
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Kongliga Svenska Vetenskap Akademien, Stockholm, Sweden.
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Leland Stanford University Library, Stanford University, Cal.
Linnean Scientific and Historical Society, Lancaster, Pa.
Linnean Society of London, Burlington House, W., London, England.
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Literary and Scientific Society, Ottawa, Canada.
Liverpool Geological Society, Liverpool, England.
Liverpool University Library, Liverpool, England.
The Lloyd Library, 224 W. Court St., Cincinnati, Ohio.
London School Board, London, England.
McGill University Library, Montreal, Canada.
Magyar Ornithologiai Koezpont, Budapest, Austria-Hungary.
K. Magyar Természettudományi Társulat, Budapest, Austria-Hungary.
Maine University Library, Orono, Maine.
Manchester Geological Society, 36 George St., Manchester, England.
Manchester University Library, Manchester, England.
Manila University Library, Manila, Philippine Islands.
Manitoba Historical and Scientific Society, Winnipeg, Manitoba, Canada.
Manitoba University Library, Winnipeg, Manitoba, Canada.
Marine Biological Laboratory, Wood's Holl, Mass.
Maryland Geological Survey, Baltimore, Md.
Massachusetts Board of Cattle Commissioners, Boston, Mass.
Massachusetts Horticultural Society, 300 Mass. Ave., Boston, Mass.
Medicinische Naturwissenschaftliche section des Siebenbuergischen Museum Verin, Klausenburg, Austria-Hungary.
Melbourne University Library, Melbourne, Australia.
Michigan Agricultural College Library, Agricultural College, Michigan.
Michigan College of Mines Library, Houghton, Michigan.
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Minister of Public Instruction, Paris, France.
Minnesota Academy of Natural Science, Minneapolis, Minn.
Minnesota University Library, Minneapolis, Minn.
Missouri Botanical Garden, St. Louis, Mo.
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Missouri University Library, Columbia, Mo.
Montana University Library, Messoula, Montana.
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Museum fuer Natur-u. Heimatkunde, Domplatz 5, Magdeburg, Germany.
Museum of Geology and Archaeology, Princeton, N. J.
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New York State Library, Albany, N. Y.
New York State Museum of Natural History, Albany, N. Y.
Newark Entomological Society, Newark, New Jersey.
Norges Geologiske Undersoegelse, Christiania, Norway.
Northampton Institute, St. Johns Street Road, London, England.
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Ohio Mechanics Institute, Cincinnati, Ohio.
Ohio State Academy of Science, Page Hall, Ohio State University, Columbus, Ohio.
Ohio State Archaeological and Historical Society, Columbus, Ohio.
Ohio State University Library, Columbus, Ohio.
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Olivet College Library, Olivet, Michigan.
Onondaga Academy of Science, Syracuse, N. Y.
Ontario Minister of Education, Ottawa, Canada.
Oregon University Library, Eugene, Oregon.
Orto Botanico, Palermo, Italy.
Oschshestvo Iestestvo-Ispytalelei pri Imper. Kazanskom Universitetie, Kazan, Russia.
Oxford University Entomological Society, Oxford, England.
Peabody Academy of Science, Salem, Mass.
Peabody Institute Library, Baltimore, Md.
Peabody Museum of American Archaeology and Ethnology, Cambridge, Mass.
Pennsylvania Geological Survey, Philadelphia, Pa.
Pennsylvania University Library, Philadelphia, Pa.
Petermanns, Dr. A., Geographiache Mitteilungen, Gotha, Germany.
Petoskey Public Library, Petoskey, Michigan.
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Philosophical Society of Glasgow, Glasgow, Scotland.
Popular Science Monthly, Sub-station 84, New York.
Portland Society of Natural History, 24 Elm St., Portland, Maine.
Princeton Academy of Science, Princeton, Ill.
Princeton University Library, Princeton, New Jersey.
Provinzial-Verein fuer Wissenschaft-u. Kunst, Muenster, Prussia, Germany.

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Real Academia de Ciencias y Artes, Barcelona, Spain.
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Rijksuniversiteit, Bibliothek, Groningen, Holland.
Rijks Universiteit, Bibliothek, Leiden, Holland.
Rijks Universiteit, Bibliothek, Utrecht, Holland.
Rivista Argentina, La Plata, South America.
Rivista Italiana di Scienze Naturali, Siena, Italy.
Rochester Academy of Science, Rochester, New York.
Royal Astronomical Society of Canada, 198 College St., Toronto, Canada.
Royal Botanic Garden, Kew, England.
Royal Botanic Garden, Sibpur, Near Calcutta, India.
Royal Botanic Society, Inner Circle, Regents Park, London, England.
Royal Dublin Society, Dublin, Ireland.
Royal Geographical Society, London, England.
Royal Geographical Society of Australasia, 3 State Bank Chambers, Adelaide, South Australia.
Royal Geological Society of Cornwall, Penzance, England.
Royal Irish Academy, Dublin, Ireland.
Royal Istituto Botanico, Palermo, Italy.
Royal London Ophthalmic Hospital, City Road, E. C. London, England.
Royal Medical and Chirurgical Society, 20 Hanover Square, London, England.
Royal Microscopical Society, Kings College, W. C. London, England.
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Saellskepet pro Fauna et Flora Fennica, Helsingfors, Finland.
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San Diego Society of Natural History, San Diego, California.
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Sociedad Agricola Mexicana, Mexico City, Mexico.
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Sociedad de Ciencias Fisicas y Naturales, Caracas, Venezuela.
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Società Adriatica di Scienze Naturali, Trieste, Austria-Hungary.
Società Entomological Italiana, Florence, Italy.
Società Italiana delle Scienze, Rome, Italy.
Società Italiana di Scienze Naturali, Milan, Italy.
Società di Scienze Naturali, Pisa, Italy.
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Société Belge de Geologie, Bruxelles, Belgium.
Société de Bilogique, Paris, France.
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Société de Sciences de Nancy, Nancy, France.
Société des Sciences Historiques et Naturelles de la Corse, Bastia, France.
Société des Sciences Historiques et Naturelles de l'Yonne, Auxerre, France.
Société des Sciences Naturelles, Neuchatel, Switzerland.
Société des Sciences Naturelles, Versailles, France.
Société des Sciences Physiques et Naturelles, Zurich, Switzerland.
Société Entomologique de Belgique, Bruxelles, Belgium.
Société Entomologique de France, Paris, France.
Société Géologique de Belgique, 25 Rue Nysten, Liege, Belgium.
Société Géologique de France, Paris, France.
Société d'Histoire Naturelle, Autun, France.
Société d'Horticulture et de Botanique, Havre, France.
Société d'Horticulture et de Botanique, Marseilles, France.
Société Linnéenne de Bordeaux, Bordeaux, France.
Société Linnéenne de Lyon, Lyon, France.
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Société Royale des Sciences, Liege, Belgium.
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Société Scientifique de Bruxelles, Bruxelles, Belgium.
Société Scientifique de Chevtshénko, Lemberg, Austria-Hungary.
Société Zoologique de France, Paris, France.
South African Association for the Advancement of Science, P. O. Box 1176, Johannesburg, South Africa.
South Dakota Geological Survey, Vermillion, South Dakota.
Spokane Academy of Science, Spokane, Washington.
State Historical Society of South Dakota, Pierce, South Dakota.
Staten Island Association of Arts and Sciences, New Brighton, New York.
Sydney University Library, Sydney, New South Wales.
Tacoma Academy of Science, Tacoma, Washington.
Texas Academy of Science, Austin, Texas.
Texas University Library, Austin, Texas.
Tokio Imperial Museum, Department of Natural History, Tokio, Japan.
Toronto University Library, Toronto, Canada.
Torrey Botanical Club, Columbia University, New York City, N. Y.
Trenton Natural History Society, Trenton, New Jersey.
Trinity University Library, Toronto, Canada.
Ufficio Centrale Meteorologico e Geodinamico, Rome, Italy.
U. S. Department of Agriculture Library, Washington, D. C.
U. S. Geological Survey, Washington, D. C.
U. S. Naval Observatory Library, Washington, D. C.
U. S. Surgeon Generals Office-Library, Washington, D. C.
Universidad Central de Espana, Biblioteca, Madrid, Spain.
Universidad de Barcelona, Bibliotheca, Barcelona, Spain.
Universidad de Chile, Biblioteca, Santiago, Chile.
Universidad Literaria de Zaragoza, Zaragoza, Spain.
Universidad Mayor de San Marcos de Lima, Biblioteca, Lima, Peru.
Universidad Nacional, Bibliotheca, Buenos Aires, Argentine Republic.
Universidad Nacional, Bibliotheca, La Plata, Argentine Republic.
Universidade de Coimbra, Bibliothek, Coimbra, Portugal.
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Universitaet Montevideo, Biblioteca, Montevideo, Uruguay, South America
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Université de Toulouse, Bibliothéque, Toulouse, France.
Universiteits Bibliotheek, Amsterdam, Netherlands.
Universite Libre de Bruxelles, Bibliotheque, Bruxelles, Belgium.
Universitatea din Bukarest, Bibliothek, Bukarest, Roumania.
University College Library, Auckland, New Zealand.

University of Vermont Library, Burlington, Vt.
University of Mexico Library, Mexico City, Mexico.
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Verein fuer Naturwissenschaften, Braunschweig, Germany.
Verein z. Verbreitung Narutwissens chaftlicher Kenntnisse, Wien, Austria-Hungary.
Vereinigate Friedrichs-Universitaet, Bibliothek, Halle, Germany.
Victoria and Albert Museum, Bombay, India.
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Washington Academy of Sciences, Washington, D. C.
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Washington Anthropological Society, Washington, D. C.
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Washington University Library, Seattle, Washington.
Washington University Library, St. Louis, Mo.
Western Reserve University Library, Cleveland, Ohio.
Western State Normal School Library, Kalamazoo, Michigan.
Wisconsin Academy of Science, Room 302 State Historical Library, Madison, Wis.
Wisconsin University Library, Madison, Wis.
Worcester Natural History Society, 12 State St., Worcester, Mass.
Yale University Forestry School, New Haven, Conn.
Yale University Library, New Haven, Conn.
Yale University Observatory, New Haven, Conn.
Yorkshire Geological and Polytechnical Society, Halifax, England.
Zentral-Bibliothek, Munich, Germany.
Zoological Society, Fairmount Park, Philadelphia, Pa.
Zoologischer Anzeiger, Leipzig, Germany.
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Wright, Luther L., Lansing.

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Bastin, Edson S., U. S. Geological Survey, Washington, D. C.
Cooper, Wm. S., Univ. of Chicago, Chicago, Ill.
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AFFILIATED SOCIETIES.

Battle Creek Nature Club, Battle Creek, Mich.
Michigan Forestry Association.

OFFICERS 1909–1910.

President, FRANK LEVERETT, Ann Arbor.
Secretary-Treasurer, *WM. S. SAYER, East Lansing.
Librarian, G. P. BURNS, Ann Arbor.
Acting Secretary-Treasurer, GEO. D. SHAFER, East Lansing.

VICE-PRESIDENTS.

Agriculture, W. J. EUSTACE, East Lansing.
Botany, C. W. KAUFFMAN, Ann Arbor.
Geography and Geology, E. C. CASE, Ann Arbor.
Sanitary and Medical Science, G. CARL HUBER, Ann Arbor.
Science Teaching, CHAS. E. BARR, Albion.
Zoology, HANSFORD MCCURDY, Alma.

PAST PRESIDENTS.

Professor W. J. BEAL, East Lansing.
Professor W. H. SHERZER, Ypsilanti.
BRYANT WALKER, ESQ., Detroit.
Professor V. M. SPALDING, Witch Creek, Cal.
DR. HENRY B. BAKER, Holland.
Professor JACOB REIGHARD, Ann Arbor.
Professor CHARLES E. BARR, Albion.
Professor V. C. VAUGHAN, Ann Arbor.
*Professor I. C. RUSSELL.
Professor F. C. NEWCOMB, Ann Arbor,
Dr. A. C. LANE, State Geologist, Lansing.
Professor W. B. BARROWS, East Lansing.
Dr. JAMES B. POLLOCK, Ann Arbor.
Professor MARK S. W. JEFFERSON, Ypsilanti.
Dr. CHARLES E. MARSHALL, East Lansing.

COUNCIL.

The Council is composed of the above named officers and all Resident Past-Presidents.

*Deceased.

REPORT OF THE TREASURER.

April 1, 1908–April 1, 1909.

Receipts:		
Balance on hand	$6 54	
All other receipts	175 85	
Total	$182 39	
Expenses.		
Printing:		
Reprints		$88 00
Programs and announcements		34 05
Membership cards and bills		4 00
Letter heads		2 85
Express		1 52
Postage and envelopes		34 72
Janitor		1 00
Total		$166 14
Balance on hand		16 25

CONSTITUTION

OF

THE MICHIGAN ACADEMY OF SCIENCE.*

ARTICLE I.

This Society shall be known as "THE MICHIGAN ACADEMY OF SCIENCE."

ARTICLE II: OBJECTS.

The objects of this Academy shall be scientific research and the diffusion of knowledge concerning the various departments of science.

ARTICLE III: MEMBERSHIP.

The Academy shall be composed of *Resident Members, Corresponding Members, Honorary Members, Patrons* and *Affiliated Societies.*

1. Resident Members shall be persons who are interested in scientific work and resident in the State of Michigan.

2. Corresponding Members shall be persons interested in science, and not resident in the State of Michigan,

3. Honorary Members shall be persons distinguished for their attainments in science, and not resident in the State of Michigan, and shall not exceed twenty-five in number.

4. Patrons shall be persons who have bestowed important favors upon the Academy, as defined in Chapter I, Paragraph 4 of the By-Laws.

5. Resident Members alone shall be entitled to vote and hold office in the Academy.

6. An affiliated society shall be a society accepted by the Council of the Academy, subject to ratification by the Academy at its next regular meeting as having as a principal object the promotion of scientific research in some line or lines, or the diffusion of scientific results in Michigan. Such a Society shall qualify as a member exactly as an individual member and shall exercise its right of membership through a delegate duly certified by the secretary of said society. Said delegate shall have all the rights of any resident member, except that the publications of the Academy shall be sent to the affiliated society as such as long as the dues of said society are paid and the secretary of the Academy not notified of the selection of a successor, and in case such society contains not less than eight resident members of the Academy such delegate shall ex-officio be a member of the Council of the Academy, as hereafter provided. And hereafter in this constitution and by-laws the word "Resident Member" shall be understood to include also said delegates, unless otherwise expressly stated.

*The history of the Academy will be found in the First Annual Report.

ARTICLE IV: Officers.

1. The officers of the Academy shall consist of a President, a Vice President of each section that may be organized, a Secretary and a Treasurer. These officers and all past presidents shall constitute an Executive Committee, which shall be called the Council.

2. The President shall discharge the usual duties of a presiding officer at all meetings of the Academy, and of the Council. He shall take cognizance of the acts of the Academy and of its officers, delegates of affiliated societies, containing a sufficient number of members of the Academy, as provided in Article III, and cause the provisions of the constitution and By-Laws to be faithfully carried into effect. He shall also give an address to the Academy at the closing meeting of the year for which he is elected.

3. The duties of the President in case of his absence or disability shall be assumed by one of the Vice Presidents who shall be designated by the Council.

The Vice Presidents shall be chairmen of their respective sections. They shall encourage and direct research in the special branches of science included within the Sections over which they preside.

4. The Secretary shall keep the records of the proceedings of the Academy and a complete list of the members, with the dates of their election and disconnection with the Academy. He shall also be the Secretary of the Council.

The Secretary shall co-operate with the President in attending to the ordinary affairs of the Society. He shall attend to the preparations, printing and mailing of circulars, blanks and notifications of elections and meetings. He shall superintend other printing ordered by the Academy, or by the President, and shall have charge of its distribution under the direction of the Council.

The Secretary, unless other provision be made, shall also act as *Editor* of the publications of the Academy and as *Librarian* and *Custodian* of property.

5. The Treasurer shall have the custody of all funds of the Academy. He shall keep an account of receipts and disbursements in detail, and this account shall be audited as hereinafter provided.

6. The Academy may elect an *Editor* to supervise all matters connected with the publication of the transactions of the Academy, under the direction of the Council, and to perform the duties of Librarian until such time as the Academy shall make that an independent office.

7. The Council is clothed with executive authority, and with the legislative powers of the Academy in the intervals between the latter's meetings; but no extraordinary act of the Council shall remain in force beyond the next following stated meeting, without ratification by the Academy. The Council shall have control of the publications of the Academy, under the provisions of the By-Laws and of the resolutions from time to time adopted. It shall receive nominations for members, and on approval, shall submit such nominations to the Academy for action. It shall have power to fill vacancies *ad interim*, in any of the offices of the Academy.

8. Terms of Office. The President, Vice President, Secretary, Treasurer and Editor shall be elected annually, and be eligible to re-election without limitation. Delegates shall remain members of the Council as long as qualified, according to Article III.

ARTICLE V: Voting and Elections.

1. *All elections* shall be by ballot. To elect a Resident Member, Corresponding Member, Honorary Member or Patron or impose any special tax shall require the assent of three-fourths of all Resident Members voting.

2. Any member may be expelled by a vote of nine-tenths of all members voting, provided notice that such a movement is contemplated be given at a meeting of the Academy three months previous to such action.

3. Election of Members. Nominations for Resident membership shall be made by two Resident Members, according to a form to be provided by the Council. One of these Resident Members must be personally acquainted with the nominee and his qualifications for membership. The Council shall submit the nominations received by them, if approved, to a vote of the Academy at a regular meeting.

4. Election of Officers. Nominations for office shall be made by the Council as provided in the By-Laws. The nominations shall be submitted to a vote of the Academy at its winter [annual] meeting. The officers thus elected shall enter upon duty at the adjournment of the meeting.

5. At the meeting in which this constitution is adopted the officers for the ensuing year shall be elected in such manner as the academy may determine.

ARTICLE VI: Meetings.

1. The Academy shall hold at least two stated meetings a year—a *summer [or Field] Meeting*, and a *Winter [or Annual] Meeting*. The date and place of each meeting shall be fixed by the Council, and announced by circular at least three months before the meeting. The programme of each meeting shall be determined by the Council, and announced beforehand, in its general features. The details of the daily sessions shall also be arranged by the Council.

2. All members must forward to the Secretary, if possible, before the convening of the Academy, full title of all papers which they propose to present during the meeting, with a statement of the time that each will occupy in delivery and a brief abstract of their contents. From the abstracts thus presented, the Council will determine the fitness of the paper for the programme.

3. This section stricken out April 1, 1898.

4. Special Meeting of the Academy may be called by the Council, and must be called upon the written request of twenty Resident Members.

5. Stated Meetings of the Council shall be held coincidently with the stated meetings of the Academy. Special meetings of the Council may be called by the President at such times as he may deem necessary.

6. Quorum. At meetings of the Academy a majority of those registered in attendance shall constitute a quorum. Four members shall constitute a quorum of the council.

ARTICLE VII: Publications.

The publications of the Academy shall be under the immediate control of the Council, but the Council shall accord to each author the right, under proper restrictions, to publish through whatever channel he may choose.

ARTICLE VIII: Sections.

Members not less than eight in number may by special permission of the Academy unite to form a section for the investigation of any branch of science. Each section shall bear the name of the science which it represents, thus: The Section of (Agriculture) of the Michigan Academy of Science.

2. Each section is empowered to perfect its own organization as limited by the Constitution and By-Laws of the Academy.

ARTICLE IX: Amendments.

This Constitution may be amended at any winter [Annual] meeting by a three-fourths vote of all the Resident Members present.

BY-LAWS.

CHAPTER I: Membership.

1. No person shall be accepted as a Resident Member unless he pay the dues for the year within three months after notification of his election. An affiliated society, after the secretary has been notified that it will be accepted as affiliated shall also be expected to pay the annual dues, but a commutation of twenty-five dollars shall be accepted for a permanent membership, The annual dues shall be one (1) dollar, payable on or before the annual meeting in advance; but a single prepayment of twenty-five (25) dollars shall be accepted as commutation for life.

2. The sums paid in commutation of dues shall be invested, and the interest used for the ordinary purposes of the Academy during the payer's life, but after his death the sum shall be covered into the Research Fund.

3. An arrearage in payment of annual dues shall deprive a Resident Member of the privilege of taking part in the management of the Academy and of receiving the publications of the Academy. An arrearage continuing over two (2) years shall be construed as notification of withdrawal.

4. Any person eligible under Article III of the Constitution may be elected Patron upon the payment of one hundred (100) dollars to the Research Fund of the Academy.

CHAPTER II: Officials.

1. The President shall countersign, if he approves, all duly authorized accounts and orders drawn on the Treasurer for the disbursement of money.

2. The Secretary, until otherwise ordered by the Academy, shall perform the duties of Editor, Librarian and Custodian of the property of the Society.

3. The Academy may elect an Assistant Secretary.

4. The Treasurer shall give bonds, with two good sureties approved by the Council, in the sum of five hundred dollars, for the faithful and honest performance of his duties, and the safe-keeping of the funds of the Academy. He may deposit the funds in bank at his discretion, but shall not invest them without the authority of the Council. His accounts shall be balanced on the first day of the Annual Meeting of each year.

5. The minutes of the proceedings of the Council shall be subject to call by the Academy.

CHAPTER III: Election of Members.

1. Nominations for Resident Membership may be proposed at any time on blanks to be supplied by the Secretary.

2. The *form* for the nomination of Resident Members shall be as follows:

In accordance with his desire, we respectfully nominate for Resident Member of the Michigan Academy of Science.

(Full name)
(Address)
(Occupation)

(Branch of science interested in, work already done, and publications, if any)

(Signed by at least two Resident Members.)

The form when filled is to be transmitted to the Secretary.

3. The Secretary shall bring all nominations before the Council at either the winter [Annual] or summer [Field] meeting of the Academy, and the Council shall signify its approval or disapproval of each. (The Secretary is delegated the power, by general action of the Academy, to accept, subject to the ratification of the Academy at its next meeting, applicants at any time upon the recommendation of two members, as now practiced, and upon the payment of one dollar, which shall cover the annual dues for the year in which it is paid, and that only.)

(Minutes, 1907.)

4. At the same or next stated meeting of the Academy, the Secretary shall present the list of candidates to the Academy for election.

5. Corresponding Members, Honorary Members, and Patrons shall be nominated by the Council, and shall be elected in the same manner as Resident Members.

CHAPTER IV: Election of Officers.

Section 1. At the Annual Meeting the election of officers shall take place and the officers elected shall enter on their duties at the end of the meeting.

Section 2. The Council shall nominate a candidate for each office, but each Section may recommend to the Council a candidate for its Vice President. Additional nominations may be made by any member of the Academy. All elections shall be made by ballot.

CHAPTER V: Financial Methods.

1. No pecuniary obligation shall be contracted without express sanction of the academy or the Council. But it is to be understood that all ordinary incidental and running expenses have the permanent sanction of the Academy, without special action.

2. The creditor of the Academy must present to the Treasurer a fully *itemized* bill, *certified* by the official ordering it, and *approved* by the President. The Treasurer shall then pay the amount out of any funds not otherwise appropriated, and the receipted bill shall be held as his voucher.

3. At each annual meeting the President shall call upon the Academy to choose two members, not members of the Council, to whom shall be referred the books of the Treasurer, duly posted and balanced to the first day of the Annual Meeting as specified in the By-Laws, Chapter III, Paragraph 4. These Auditors shall examine the accounts and vouchers of the Treasurer, and any member or members of the Council may be present during the examination. The report of the Auditors shall be rendered to the Academy before the adjournment of the meeting and the Academy shall take appropriate action.

CHAPTER VI: Publications.

1. The publications are in charge of the Council and under their control, limited only as given by Article VII of the Constitution.

2. One copy of each publication shall be sent to each Resident Member, Corresponding Member, Honorary Member, and Patron, and each author

shall receive fifty copies of his memoir. This provision shall not be understood as including publications in journals not controlled by the Academy. [By recent ruling, authors receive no reprints free. If reprints are wanted the Academy will pay two-thirds if the author pays one-third the cost of printing not to exceed fifty copies. The author may have as many more than fifty provided he bears the whole expense of those above fifty.] (Minutes of 1906.)

CHAPTER VII: The Research Fund.

1. The Research Fund shall consist of moneys paid by the general public for publications of the Academy, of donations made in aid of research, and of the sums paid in commutation of dues according to the By-Laws, Chapter I, Paragraphs 2 and 4.

2. Donors to this fund not members of the Academy, in the sum of twenty-five dollars, shall be entitled without charge to the publications subsequently appearing.

CHAPTER VIII: Order of Business.

1. The order of business at the Winter [Annual] Meetings shall be as follows:

(1) Call to order by the presiding officer.
(2) Introductory ceremonies.
(3) Statements by the President.
(4) Report by the Council.
(5) Report of the Treasurer, and appointment of the Auditing Committee.
(6) Election of officers of the next ensuing administration.
(7) Election of members.
(8) Announcement of the hour and place for the address of the retiring President.
(9) Necrological notices.
(10) Miscellaneous announcements.
(11) Business motions and resolutions, and disposal thereof.
(12) Reports of committees and disposal thereof.
(13) Miscellaneous motions and resolutions.
(14) Presentation of memoirs.

2. At an *adjourned session*, the order shall be resumed at the place reached on the previous adjournment, but new announcements, motions and resolutions will be in order before the resumption of the business pending at the adjournment of the last preceding session.

3. At the *Summer* [*Field*] *Meeting* the items of business under numbers (5), (6), (8), (9), shall be omitted.

4. At any *Special Meeting* the Order of Business shall be (1), (2), (3), (7), (10), followed by the special business for which the meeting was called.

CHAPTER IX: Amendments.

These By-Laws may be amended by a majority vote of the members present at any regular meeting.

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